EVALUATING HOW ATTRIBUTES OF OPERABLE WINDOW DESIGN

AFFECT OFFICE-WORKERS' PERCEPTION

OF PERSONAL CONTROL

by

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A THESIS

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"Evaluating How Attributes of Operable Window Design Affect Office-workers' Perception of Personal Control," a thesis prepared by Joan Marie Vorderbruggen in partial fulfillment of the requirements for the Master of Architecture degree in the Department of Architecture. This thesis has been approved and accepted by:

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Energy and environmental concerns warrant reconsideration of operable windows as a means of ventilating and cooling office environments. To design for optimal window use and performance, architects must understand human interaction with operable windows and the factors that influence occupant participation in their thermal environment.

This thesis examines workers' personal control of operable windows in their office space through the lens of the following attributes: proximity, orientation, and accessibility to operable windows, office floor height, and the operational methods of windows. Three sites in the Minneapolis metro area were examined through site visits, informal

interviews, collection of physical traces, and a questionnaire. Research data reveal that proximity is the greatest determinant of window use. Other attributes have varying degrees of influence on use of windows. Surprisingly, workers valued operable windows significantly more for fresh air than for cooling.

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To Darryl,

Whose unwavering support is appreciated more than he knows.

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CHAPTER I

INTRODUCTION

High costs associated with fossil fuel consumption - increasing energy prices and degradation to the environment through climate change – along with concerns of health and productivity of occupants in hermetically sealed buildings has awakened an interest in natural ventilation through operable window implementation (Nicol 2007; Solomon 2007; Wagner, Gossauer, Moosmann, Gropp & Leonhart 2007; Brager 2006; Germano 2006; Nicol & Humphreys 2002).

Incorporating operable windows[1] for natural ventilation[2] in the workplace not only addresses environmental and economic impact by reducing the energy load of buildings, but also has been found to benefit human well being (Kellert 2005), in contrast to spaces with mechanical ventilation (Butala & Muhic 2007; Muhic & Butala 2004). According to Solomon (2007), "People are again becoming more aware of the buildings they inhabit and want to regain the ability to effect changes to their personal environments." Operable windows allow occupants a sense of personal control, which is greatly valued in the office environment (Paul & Taylor 2008; Wagner et al. 2007; Zhang, Arens, Abbaszadeh, Huizenga, Paliaga, Brager & Zagreus 2007; Huizenga, Abbaszadeh, Zagreus & Arens 2006; Hummelgard 2005; Humphreys 2005;

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[1] For this study, *operable windows* may include several window types (awning, double hung, casement, etc.) that can be used by individual office occupants, or a group of assigned office occupants, as a means of controlling the thermal environment in their immediate work zone. Operable windows will not be limited to the time of the day used. If mechanical assistance of moving air (fans, stack effect, etc.) is used to assist the flow of ventilation, it will be mentioned. Operable windows will be considered as a part of an exterior wall system, separating interior space from exterior space.

[2] Natural ventilation is any form of passive ventilation that allows for fresh air to enter a building through non-mechanical means. Natural ventilation is not effective if the temperature outside is warmer than the indoor temperature, or if there is not sufficient draw through cross ventilation or stack effect.

Mahdavi & Unzeitig 2005). Incorporation of operable windows has also been shown to increase the range of acceptable thermal comfort by users (Brager, Paliaga & DeDear 2004).

1.1 The Problem

This thesis seeks to identify those attributes of operable window design that impact users' perception of personal control in an office environment. To better understand how to design buildings that consume fewer resources and are healthy to occupy, architects are charged with looking both forward to new innovation and technologies, and backward to natural and passive strategies that were employed prior to the mid twentieth century. Natural ventilation through operable windows is one of many green strategies again being implemented into building design; yet there is still not a strong indication of utilization of those strategies requiring occupant participation.

The simple questions – Are people actually opening their windows, and what determines window use? - seem rudimentary. Yet they are an essential link to ensuring that buildings designed with operable windows for energy efficiency and improved human comfort are actually going to achieve those goals.

Understanding what variables contribute to the occupants' perceived and realized level of personal control of their environment is critical in understanding window use, and in maximizing thermal comfort and energy conservation. (Herkel, Knapp, & Pfafferott 2008; Gratia, Bruyere, & DeHerde 2004). An area not yet extensively researched - the physical attributes of window design related to window use in office spaces – is worthy of further focus. These are the design decisions made by architects and facility managers that can have an impact on human, environment and economy.

The relationship between attributes of operable window design can influence perception of personal control by occupants, and consequently how they utilize the windows. Operating mechanisms and controls that allow for transparent, easy implementation (Solomon 2007), and other attributes such as window location and orientation, office layout (Yildirim, Akalin-Baskay, & Celebi

2007), and occupant proximity (Gratia et al. 2004; Zagreus, Huizenga, Arens & Lehrer 2004) should all be considered in the design process to ensure optimal implementation of operable windows.

1.2 Defining the Design Attributes of Operable Windows

For this thesis, the physical attributes of operable window design are considered to be those architectural considerations not only pertaining to window design, but also design decisions that affect an occupant's physical interaction and relationship with windows in their office space. They can be categorized under the umbrella of attributes that contribute to the occupant's likelihood for personally controlling the windows and are listed as follows:

(1) Window operational method (i.e. double-hung, casement, awning, etc.)

(2) Window accessibility (vertical position of window from the floor; accessibility of window itself related to obstructions; clear view and accessibility of window handle, latch, or operating hardware)

(3) Physical proximity of occupants in relationship to operable windows (immediate access, or separated by other work stations, circulation space, etc.)

(4) Window orientation

(5) Outside floor height as measured from ground

1.3 Research Questions

The primary question addressed in this research is:

1. What are the design attributes of operable windows that allow windows to be used by office occupants for controlling thermal comfort and natural ventilation?

Secondary questions followed:

2. What window design attributes have the greatest effect on occupants' perception of personal control of natural ventilation through windows?

3. What design attributes have minimal or minor effect on occupants' use of windows and perception of personal control?

4. What are the benefits and limitations of operable windows as cited by office occupants?

1.4 Objectives and Relevance

This topic addresses issues of human and environmental health through the investigation of a specific building element – an operable window. A seemingly qualitative issue of building design, human health and personal control of one's environment has begun to be recognized as an important issue related to energy, productivity, and environmental costs of building construction and operation (Wagner et al. 2007). Guidelines used by architectural practitioners, such as LEED[3], have also recently begun to address the issues of human health and personal control (Lewis 2007; Zimmerman 2004), suggesting an acknowledgment of the relevance of these considerations within the design profession.

1.4.1 Research Objectives

Focusing on office spaces potentially allows for a significant amount of the working population to be served by the outcomes. Through comparative case studies of office spaces that have incorporated operable windows, this thesis endeavors to provide empirical evidence related to the attributes of operable window design that may either encourage or discourage building occupants to personally control the windows.

An extensive literature review enabled the identification of research areas to be served. In its design, the research methodology addresses both the qualitative and quantitative issues pertaining to the overall problem, with outcomes to be shared with the design community. The results of this thesis can further a dialogue pertaining to the relationship between human behavior, personal perception and personal control, and the success or failure of particular design strategies.

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[3] LEED – Leadership in Energy and Environmental Design, a standardized green building rating system managed by the US Green Building Council (USGBC).

1.4.2 Relevance to the Profession

Understanding how design decisions can influence occupant use of operable windows, and reciprocally, how human behavior can inform design decisions, can allow architects to better comprehend necessary considerations during the design process. The results of this research are to be shared with the architecture profession, to produce a meaningful outcome for operable window use in an office environment.

1.5 Research Planning and Design

Determinants of operable window use has been the topic of research prior to this thesis, although there remains limited evidence of research into the relationship between the physical considerations of operable window design and human behavior and perception. Investigation of operable window use related to thermal comfort and ventilation (Breesch, Bossaer & Janssens 2005), and user behavior associated with outdoor temperatures, seasons, and occupancy patterns (Herkel et al. 2008) has assisted in determining when occupants are more likely to utilize operable windows.

A multitude of studies have focused on barriers to operable window use, such as noise, or air-borne particulates outside office buildings (Butala & Muhic 2007; Loupa, Kioutsioukis, & Rapsomonikis 2007; Germano, 2006; Ghiaus, Allard, Santamouris, Georgakis & Nicol 2006; Oldham, DeSalis, & Sharples 2004; DeSalis, Oldham, & Sharples 2002; Nicol & Wilson 2004; Nicol & Humphreys 2002).

While the above-mentioned studies have offered insight into the relationship between office occupants and their use of operable windows, this research expands the understanding of those architectural decisions that can be measured and documented: physical attributes of design directly related to real and perceived interaction potential with operable windows.

Research design consisted of data collection through the investigation of three office buildings that have incorporated operable windows into their mode of cooling and ventilation. Through documentation, informal interviews with occupants, and a web-based survey, the following attributes were analyzed

through both qualitative and quantitative methodologies: (1) window operational method, (2) window accessibility as related to window position, (3) occupant proximity to windows, (4) window orientation, and (5) floor height. This will be discussed in detail in Chapter 4. The following diagram (Figure 1.1) reveals the circuitous and reciprocal relationship of designed attributes on operable windows and human behavior, as this research sought to comprehend more clearly.
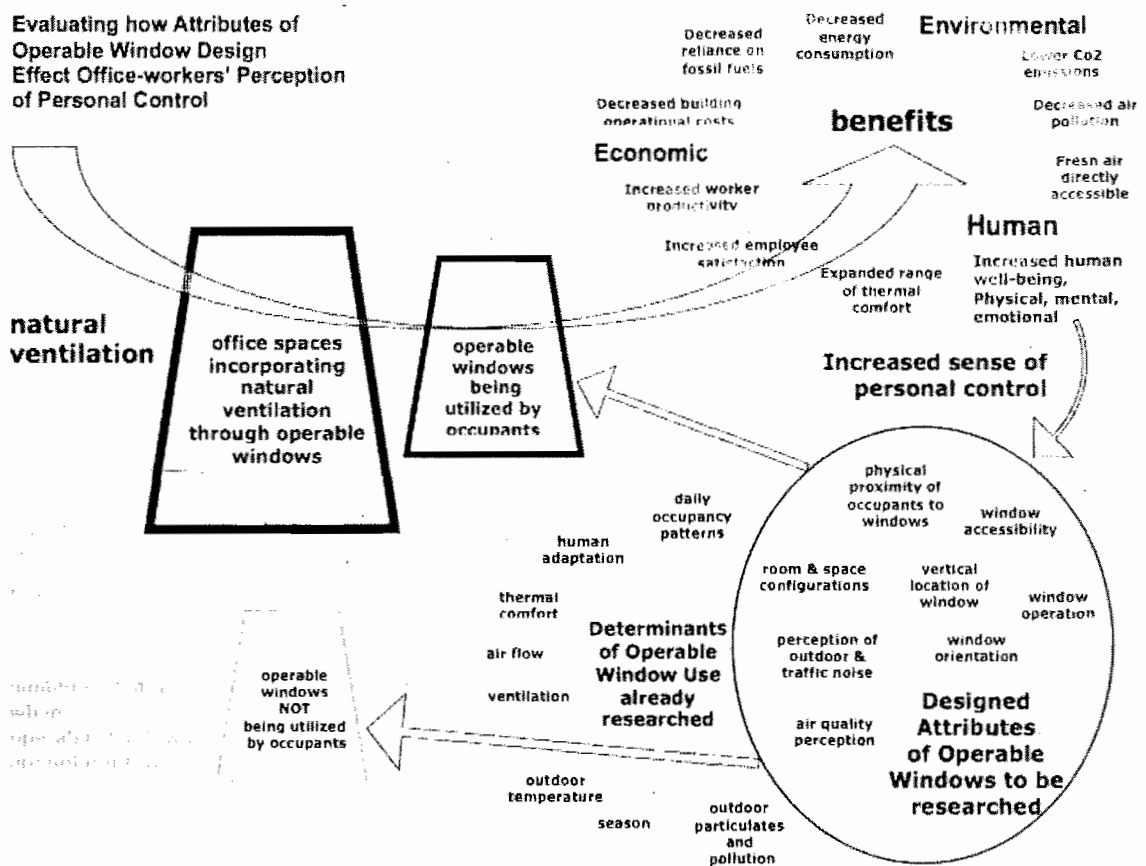
Figure 1.1 Research Design

1.6 Research Outline and Limitations

In the following chapters, the research will be further described in detail. Chapter II consists of a discussion of previous research pertaining not only to operable windows, but natural ventilation, thermal comfort, personal control, and environmental and energy related issues. Chapter III will describe the methodologies employed and Chapter IV will discuss the results of the research findings and analysis of them. Chapter V will offer conclusions, as well as suggestions for future research.

A number of issues informed and circumscribed this thesis. There is already an enormous amount of research on the determinants of operable window use, related to thermal comfort, ventilation, outdoor factors, and occupancy patterns in office spaces, and other building typologies. These may be touched on only if they offer direct information relating to the design attributes this research is focusing on. While natural ventilation has proven to have ramifications in the larger categories of environment and economy, those issues will only be addressed in the broader scope. Human benefits, specifically regarding a sense of personal control in the office environment, is a primary focus of this thesis, as well as those design decisions that allow for that personal control of operable windows to occur.

The determination of controlled variables was to maximize those factors that might be perceived as barriers to operable window use. Given that the offices researched were designed with the intention of operable window utilization and personal control, it stands to reason that selecting situations that might hinder window use will ultimately aid in understanding how to overcome those issues when there is a desire for window use.

Common criteria among the buildings researched consist of these variables, eliminating buildings not contained within these categories:

Controlled Variables

- LEED or non-LEED buildings that have been designed to utilize operable windows
- Office buildings that allow for occupant control of the operable windows
- Office buildings that are 6 stories or less.
- Primarily open-office plan (questionnaires will indicate location of seating in proximity to window, and level of control over operable window)
- Urban buildings (with surrounding neighborhood details addressed in each case)
- Located in Minneapolis, Minnesota's metropolitan area, for consistency in climate and cultural attitude towards operable windows.
- Operable windows open directly to the outside (not double skin façade, atrium, etc)
- Similar office culture and attitude
- Similar office hierarchy structures

Case study characteristics, as well as further limitations will be described in depth in the following chapters.

CHAPTER II

OPERABLE WINDOWS

> *"Even though studies have shown blue to be the most restful color, I doubt that anyone would put forth an argument for a monochromatic world. And yet a steady-state thermal environment is the prevailing standard for office buildings, schools, and homes across the United States."*
>
> *(Lisa Heschong, Thermal Delight in Architecture)*

2.1 Importance of this Research

Concerns about energy efficiency, environmental impact, human well-being, and - presumably the issue at the forefront of most minds currently - the economy have fueled the growth of green building movement. Because building design can touch all of these aspects, it is important that architects and engineers clearly understand the ramifications of their design decisions. Research focused on human/building interaction is paramount in learning how to design buildings that can be more transparent in their use and in what outcomes will occur with that use.

Naturally ventilated buildings offer many benefits, which will be discussed later in this chapter; but operable windows can also contribute to a general lack of control and predictability of the thermal environment. The factor of human behavior in this equation makes some building designers (mechanical engineers in particular) uncomfortable (Brager 2006).

> We need better ways to quantify the ways in which people interact with the building, modifying their own environment, and play a vital role in that optimization. Modeling the old adage, "passive buildings require active occupants," will be required in the next generation of energy simulation programs (Brager et al. 2004).

Comprehending the intricate relationship between human behavior and operable windows, through simulation or data collection, can greatly assist in our designs to allow for natural ventilation of office spaces, maximizing human comfort, energy conservation, environment and economy (Herkel et al. 2008; Gratia et al. 2004).

An AIA[4] COTE[5] web-based article stated that energy is a "design topic, not a technology topic" (Knowles 2007), one that considers people's experiences. Suggestions of countering or complementing technology by such simple solutions as "opening the windows" should be considered, but with the greater understanding of where windows are placed within a building, when to open them, and what type of windows (currently available or potential new generation) might be best. This research endeavors to assist the design profession by bringing forward new information upon which to base design decisions.

2.2 Previous Research Related to this Topic

Exploration of previous research reveals determinants to occupants' utilization of operable windows in office spaces: operable window use related to thermal comfort and ventilation preferences (Breesch et al. 2005), and user behavior associated with outdoor temperatures, seasons, and occupancy patterns (Herkel et al. 2008).

Some studies investigate barriers to operable window use, such as noise or air-borne particulate encroachment from outside (Butala & Muhic 2007; Loupa et al. 2007; Germano 2006; Ghias et al. 2006; Oldham et al. 2004; DeSalis et al. 2002; Nicol & Wilson 2004; Nicol & Humphreys, 2002). Other concerns previously researched are air pressure management, indoor air quality, freezing and water damage to windows (Ivanovich 2002), and balancing mechanical and natural ventilation (Daly 2002). Some cite mechanical

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[4] American Institute of Architects

[5] Committee on the Environment, an AIA focus group

engineers and uneducated users as barriers to operable window use (Madsen 2005).

There is a vast amount of research on the human health benefits of natural ventilation and sense of personal control associated with use of operable windows (Paul & Taylor 2008; Hummelgard, Juhl, Saebjornsson, Clausen, Toftum & Langkilde 2007; Wagner et al. 2007; Zhang et al. 2007; Huizenga, et al. 2006; Humphreys 2005; Mahdavi & Unzeitig 2005). Studies have revealed that natural ventilation increases occupant satisfaction and tolerance for the variations in thermal conditions (Humphreys & Hancock 2007). Some of these issues will be discussed in more detail in this chapter, as they are pertinent to this thesis.

The literature review also revealed a plethora of benefits of using natural ventilation through operable windows pertaining to environmental, economic, and energy issues. These will be touched on briefly, only to stress the far-reaching effects of efficient use of operable windows, in part determined by the design attributes related to those windows. These findings aided in providing a framework for this research, offering validity and support to the focus of this exploration.

2.3 Operable Windows

For the purposes of this study, operable windows will be defined as those windows that are part of an exterior wall system of a building, separating interior space from exterior space. They may come in a variety of types or configurations, but will be considered as usable by building occupants as a means of controlling the thermal environment within their workspace. Operable windows are considered to be just one of several methods or combined systems for natural ventilation within a building, and can be used effectively when outside temperature conditions are cooler than indoor temperatures (for cooling), or when there is sufficient draw to ventilate indoor spaces. In this thesis, the site of Minneapolis, Minnesota has conditions that can be favorable for use of operable windows for about 6 to 7 months of the year (Appendix A).

Building occupants love them.
Mechanical engineers hate them.
Operable windows, though simple and familiar,
have not found widespread acceptance in modern
commercial buildings in the United States. (Daly 2002)

Literature review findings of operable windows and natural ventilation reveal that most of the research heralds from countries other than the United States. Many studies from Europe/UK compare Natural Ventilation with mechanical ventilation, and while they mention factors such as occupant control, or well being created with views through windows, there is not always a clear indication that the natural ventilation system tested in the studies is exclusively derived from operable windows. This ambiguity raised several questions:

- When compared to the U.S., are operable windows in other countries so much more prevalent that it is just assumed that natural ventilation is synonymous with operable windows?

- What *are* the cultural differences of both perception and incorporation of operable windows?

- Do Americans have a more rigid or narrow expectation of what the indoor environment must feel like?

While these questions will not be addressed directly within the parameters of this research, they do come into consideration when interpreting the previous research conducted on operable windows and natural ventilation.

"The steady-state approach to the thermal environment
assumes that any degree of thermal stress is undesirable.
A constant temperature is maintained in order to save
people from the effort and the distraction of adjusting to
different conditions. And yet, in spite of the extra
physiological effort required to adjust to thermal stimuli,
people definitely seem to enjoy a range of temperatures.
Indeed, they frequently seek out an extreme thermal
environment for recreation or vacations."

(Lisa Heschong,
Thermal Delight in Architecture)

2.3.1 Natural Ventilation & Thermal Comfort

Breesch et al. found that the passive cooling of natural ventilation plays a significant role in the thermal comfort of office workers (2005). Natural ventilation through operable windows can only be effective if the windows are being used in an efficient manner. From a human standpoint, what determines whether or not windows get used?

A 2001 study of office workers determined that opening windows [and pulling blinds] is usually a response to occupant discomfort with the indoor temperature (Raja, Nicol, McCartney & Humphreys). Similarly, the Adaptive Approach to Human Comfort, cited in a 2007 study (Rijal, Touhy, Humphreys, Nicol, Samuel & Clarke), indicates that people will take action with building controls to improve their sense of comfort: "If a change occurs such as to produce discomfort, people react in ways to restore their comfort." Follow-up questions then might be "What is considered comfortable, for whom is it comfortable, and when is it comfortable?" – and there are certainly more.

Multiple sensory determinants of thermal comfort have been studied, in order to find how building occupants determine if, or which aspect takes precedence when determining their level of personal comfort (Mahdavi & Unzeitig 2005; Pellerin & Candas 2003; Elzeyadi 2002; Toftum 2002). The interplay of activity levels, noise, air quality, air flow, visual comfort, time, personal judgment, cultural perspective, personal sensitivity levels ... all can have an effect on how thermal comfort is rated and valued.

The scale of subjective comfort by ASHRAE[6] places "neutral" (not too warm or too cold) as a zero, leading many to interpret and design with the idea that neutrality is what people choose (Humphreys & Hancock 2007). "Thermally neutral" is the base line to determine how mechanical heating, ventilation and air conditioning (HVAC) systems are designed to accommodate the majority of people (Muhic & Butala 2004); but does thermal neutrality satisfy the majority?

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[6] American Society of Heating, Refrigeration and Air-conditioning Engineers

Research conducted in the UK by Humphreys and Hancock indicates that on 57% of the occasions, participants (students in a lecture hall and residents in a housing community) preferred temperatures other than neutral, choosing "slightly warm" most often. The study also revealed that the same person does not always prefer the same temperature, even when they are in the same environment each time they are surveyed. This supports the notion of subjectivity and multiple aspects of influence on human comfort (2007).

In a study of office workers' preferences in naturally ventilated buildings, occupants indicated their desire for more, rather than less airflow (Zhang et al. 2007). Most occupants wanted higher airflow rate over ASHRAE Standard 55[7], especially in the summer. This study also revealed reasons why occupants open windows ("to feel cool," "to feel more air movement," or "to let in fresh air") or close windows (primarily "to reduce outdoor noises").

The reasons *why* people open windows are of course predicated on the possibility that people can open them in the first place. Personal control of one's environment will be discussed in depth later in this chapter, but it has been shown to play a role in the perception of what constitutes thermal comfort:

> In buildings where the occupants are in control, variability may result from people adjusting conditions to suit themselves. A certain amount of variability then becomes a 'good thing.' Many naturally ventilated buildings give their occupants a certain amount of control over their environment. If the control is left to the manager (through the HVAC system) there is a smaller envelope of acceptable conditions, comfort changes more quickly with temperature and the occupants appear less forgiving (Nicol & Humphreys 2002).

2.3.2 The Inter-connectedness of Environment, Energy, and Economics

Related to the previous section, an editorial in an issue of *Energy and Buildings* asked the question, "Why is thermal comfort important to energy use?" It sought to address that energy consumption is closely related to human comfort, that comfort can affect occupant well being and health, and that

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[7] ASHRAE Standard 55 – Thermal Conditions for Human Occupancy. Specifies the combination of indoor thermal environmental factors and personal factors that will produce thermal environmental conditions acceptable to a majority off the occupants within the space. (ASHRAE.org)

discomfort can cause occupants "to take actions that may compromise the energy and economy of the building" (Nicol 2007). If people are hot, they open the window. If they are too cool, they close the window. Simple and obvious, but how can this information be applied in some quantifiable means when interpreting human behavior with respect to energy-conscious building design? Human behavior has huge implications for energy simulations used in performance analysis and certification of buildings (Rijal et al. 2007).

When looking at operable windows, it becomes apparent how enmeshed seemingly diverse issues can become: human behavior and energy efficiency, increased personal control, worker performance, and economic payback. It is equally difficult to single out the benefits that natural ventilation have on the environment specifically, or on energy or economics. The literature reviews reveal the depth of inter-relatedness among those issues:

> The considerable advantages and benefits of natural ventilation for the building owner, the occupants and the population at large include reduced capital costs as there is no mechanical plant to install; the operating costs are minimal; there is zero ecological damage and the occupants have greater personal control over their environment with greater user flexibility (Saunders, 2002, pg 139).

Other environmental, economic, and energy related research found that the advantages to natural ventilation could be quantified in "reduced construction costs, simpler and more user-manageable environmental control, reduced use of mechanical refrigeration and reduced requirement of space for services (as cited in CIBSE[8], (DeSalis et al. 2002).

In field studies conducted by Wagner et al., passive systems proved to be highly effective for reducing energy costs and reducing initial investment and operating overhead in offices. Their study sought to find out if occupants' physiological and psychological needs were being met, and how their productivity was affected. This study focused on the concept that personnel costs are one of a business's highest operating expenses, and human comfort

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[8] CIBSE: Chartered Institution of Building Services Engineers, A UK-based institution similar to the U.S. ASHRAE.

issues play an important role in that equation (2007). Similar sentiments are illustrated by G.Z Brown: "Because the cost of salary and benefits for occupants is typically several times greater than the cost of energy, even small increases in productivity can easily yield benefits that far exceed those from energy savings" (2004, pg. 14).

Related to the current economic, environmental and energy situations, there is greater support at government levels in designing with a lower carbon footprint[9]. Legislation is being passed from municipal to federal levels of government calling for new buildings to be more energy and resource-efficient (McLennan & Rumsey 2003). References to "Architecture 2030"[10] and "LEED" are making their way into design professionals' vocabulary, and the American Institute of Architects (AIA) now requires that some of the continuing education credits required for Health, Safety and Welfare be in the area of sustainable design (AIA.org).

In addition, there is some critique of implementation of certain "green" strategies, especially when earning credits for LEED certification levels. There is concern that follow-up evaluations of the effectiveness of those strategies are not always done (Lewis 2007), and such things as operable windows, which may have contributed to a building's high LEED ratings, are not even used.

Hence, the importance of understanding human behavior related to passive system utilization – specifically that of operable windows – is an important and necessary step in designing buildings that are truly more energy efficient and more advantageous to environmental and economic concerns at all levels.

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[9] Carbon Footprint: The carbon footprint is a measurement of all greenhouse gases we individually produce and has units of tons (or kg) of carbon dioxide equivalent.

[10] Architecture 2030, started by architect Ed Mazria as a grassroots organization, now implemented in some government building initiatives and recognized by the AIA. (Architecture2030.org)

2.3.3 Health Benefits

Natural ventilation has been shown to provide health benefits to building occupants (DeSalis et al. 2002). The degree to which this statement is true varies among researchers, but the literature review indicates that natural ventilation (though not always specific to operable windows) does have a positive impact on physical and mental health of office occupants (Gratia & DeHerde 2003). In his book, Saunders has cited similar findings: "compared to when in mechanically ventilated buildings, staff feel more invigorated, enjoy the sense of breathing in fresh air, and generally do not suffer the usual high absenteeism and health problems encountered in sealed environments" (2002, pg 139).

Kellert relates similar research findings in his book (2005, pg 23): "Research suggests that workers who have greater contact with nature – be it natural lighting, natural ventilation... generally have better physical, emotional, and intellectual well-being." He goes on to state: "Improved natural lighting and ventilation have been correlated with a 6 to 16 percent increase in worker productivity. Contact with nature [including windows] has also been reported to result in substantially improved quality of work, reduction in errors, fewer manufacturing defects, lower absenteeism, and lower sickness rates, all of which frequently produce significant economic savings" (pg 25). Surveys taken by Zhang et al., indicated that 60% of employees felt that good air movement from natural ventilation actually enhanced their performance (2007).

In two different studies (2007 & 2004), Butala and Muhic compared a naturally ventilated office and two mechanically ventilated offices. They found that 51% and 57% of occupants in the mechanically ventilated buildings cited health problems associated with the ventilation system, while only 12% of occupants in naturally ventilated buildings attributed health problems to ventilation. In these studies, they found no significant difference in actual physical health status related to ventilation.

As we now know, physical and mental health are mutually interdependent. When considering occupant health issues, whether real or

perceived, findings suggest a preference to naturally ventilated spaces (Hummelgaard et al. 2007).

2.3.3.1 Personal Control

A sub-category of human health, in this case primarily psychological health, is the notion of personal control. Being able to dictate, to a certain extent, one's thermal environment in the office has been found to be an important factor in worker satisfaction and productivity (Paul & Taylor 2008; Hummelgard et al. 2007; Pfafferott, Herkel, Kalz, & Zeuschner 2007; Wagner et al. 2007; Zhang et al. 2007; Huizenga et al. 2006; Humphreys 2005; Mahdavi & Unzeitig 2005; Brown 2004; Nicol & Humphreys 2002; Saunders 2002).

Operable windows are one way to allow for personal control within the work environment. Personal control and natural ventilation are cited as the most important advantages of operable windows (Madsen, 2005), though having operable windows within an office space does not guarantee that all have access to them, or that they are used. In a study of personal control and operable windows (2006), Germano made the assumption that occupants *actually knew* that they are able to use the windows – yet a potential problem in some buildings with natural ventilation is that occupants have no idea that they can open the windows!

The Center for the Built Environment at the University of California Berkeley conducted an extensive survey of 215 buildings (mostly U.S.) with over 34,000 survey responses. "We show very clearly that personal control over environmental conditions (e.g. thermostat or operable window) has a significant positive impact on occupant satisfaction. One means of achieving higher occupant satisfaction would be to provide such control to more occupants" (Huizenga, et al. 2006).

The ramifications of higher occupant satisfaction go beyond psychological well being, of course, as this literature review has already indicated. Higher employee productivity is an economic advantage to any business. In 2004, Brager et al. looked at the potential for lowering energy

consumption, based on a higher tolerance for warmer temperatures when occupants have the ability to personally control their environment:

> Ideal comfort temperatures were not only influenced by season, but by the degree of personal control. Subjects who have more control over thermal conditions of their workplace (in particular, the operable window) had a neutral temperature that was 1.5^0C (2.7^0F) warmer than subjects with minimal control, even though they experienced the same thermal environment.... This finding provides clear evidence that subjects with greater access to control are more tolerant of, and in fact may prefer, conditions that may not be in the center of the comfort zone.

Research reveals numerous instances, where, when given the opportunity and understanding to engage with passive systems, people will use those systems. A field study of naturally ventilated office spaces in the UK established that windows are used extensively as a means of individual occupant control over their thermal environment, followed by other methods such as opening doors, fans, shades, and blinds (Raja et al. 2001).

It is also determined that the *ability* to alter one's environment through opening and closing windows, drawing blinds, using a fan, adding a layer of clothing, etc. allows occupants the opportunity for personal control, which seems to be a factor in determining human comfort (Nicol & Humphreys 2002). This might even suggest that just knowing one can control his/her thermal environment would be beneficial.

Designing office spaces to allow for personal control through operable windows means understanding the holistic, inter-related systems (technological, human, natural) more clearly, and educating building users. "It's not as simple as 'opening a window and it works,' " (Madsen 2005). "It is critical that buildings be designed so that occupants can be active participants in the indoor climate feedback loop, not simply passive recipients of whatever thermal conditions the building management system delivers" (Brager et al. 2004).

2.4 Design Attributes of Operable Windows

The connection between operable window use and the perception of personal control of office workers can hinge on a number of factors, some of which have already been discussed. This thesis will focus on the attributes that contribute to the occupant's likelihood for personally controlling the windows in their office environment. These are the physical attributes of operable window design that can be determined by architects, which include not only the window itself, but the placement of the windows and relationship of occupants to the windows. These attributes will be discussed below.

2.4.1 Operational Method of Operable Windows

The method of operation applies to the window size, and type, and affects window design and facility maintenance issues. This is an area directly related to decisions that architects make regarding operable windows, and something that they should have a good understanding of, as Solomon relates when speaking of operable windows: "Designers must consider the transparency and ease of use of all operating mechanisms and controls" (2006).

The design implications of research in this area may assist in:
- Understanding how window design and size might influence the ability of occupants to interact with window, due to window weight, transparency of operation method, and ease of operation.
- Understanding if location, style, and condition of window hardware plays a role in window use.
- Understanding if window condition has a significant influence on occupant use.

2.4.2 Physical Proximity of Occupants to Windows

Research relating to work space layout indicates a correlation between occupant proximity to windows (including operable windows) and higher job satisfaction and perceived work performance (Yildirim et al. 2007; Mahdavi & Unzeitig 2005; Zagreus et al. 2004; Baskaya & Eken 2003).

The reviewed research, as well as this thesis, may reveal a benefit for architects to design for workstations situated in close proximity to windows, or

allow for more direct access (visual, thermal, physical) between workspace and window. These decisions can go as far as influencing the width and configuration of the floor plate and building width of an office plan.

The design implications of research in this area may assist in:
- Understanding degrees of distance between occupant and window that an office occupant will travel to use the window.
- Understanding if or how many workstations between an occupant and window might deter window use by the occupant in question.
- Determining whether people perceive a common space or walkway as providing more accessibility to operable windows (more democratic), than does a workstation directly adjacent to the window.
- Determining whether a common space or walkway is perceived as a barrier to the use of operable windows.

Findings by Zagreus et al. led to their statement: "It is essential that the occupants have direct control over the windows, and not simply be working in a building in which operable windows exist. This information is likely to be of interest to both the research and building design community" (2004).

2.4.3 Window Accessibility

Accessibility to the window itself is part of this research, and although mentioned interchangeably with window proximity in researched literature, there exists a slightly more detailed breakdown regarding access to windows. Factors such as the openness of floor space in front of the windows, blinds or shades that may deter access, and objects or clutter on windowsills are addressed.

This research also considers accessibility to mean the weight or heaviness of the windows related to their ease of operation, and the positioning of the window on the wall, again related to the ease or difficulty in reaching the windows to open them. These issues touch on window design and universal design, and can affect office storage and window shading decisions by designers.

The design implications of research in this area may assist in:

- Understanding how design of the window itself, related to size, weight, hardware accessibility, may influence window use.
- Understanding the extent to which blinds/shades might interfere with operable window use.
- Determining if sill clutter/obstructions alter window use (or is clutter on sills a symptom of non-use of windows?)
- Determining if floor clutter/obstructions alter window use (or is this also a symptom of non-use?).
- Determining if the vertical height of the operating hardware of a window prohibits window use.
- Understanding ergonomics, and the comfortable range of human motion that either encourages or discourages window use.

2.4.4 Window Orientation

Architects need to clearly understand the site and orientation when incorporating operable windows, not only for sun, wind, and light, but for views, vegetation, sound/noise sources, and potential pollution sources.

This thesis seeks to find connections between use of operable windows and the orientation of those windows. Initially, more focus was placed strictly on urban noise ingress through operable windows, as noise has been found to be a negative aspect of operable windows. While still included as an aspect of the research, the thesis focus changed due to the enormous amount of research already conducted in the area of urban noise and the office environment: Dogrusoy & Tureyen 2007; Loupa et al. 2007; Sim 2007; Ghiaus, et al. 2006; Gratia, Bruyere, & DeHerde 2004; Gratia & DeHerde 2004; Nicol & Wilson 2004; Oldham et al. 2004; Pasquay 2004; Gratia & DeHerde 2003; Pellerin & Candas 2003; DeSalis et al. 2002; Toftum, 2002; Sailer & Hassenzahl 2000; European Communities 2000; Veld & Passlack-Zwaans1998; U.S. Dept. of HUD 1985).

Further research has been conducted in areas of outdoor particulates entering through open windows (Loupa et al. 2007; Germano 2006; Ghiaus et al. 2006; Gratia et al. 2004), solar gain, and use of shades or blinds (Zhang et al. 2007) – all as inhibitors of operable window use. These areas are all touched on in this thesis, under the category of window orientation related to the planning and design of office spaces.

The design implications of research in this area may assist in:

- Understanding the implications of operable window orientation related to solar gain (if shades will be drawn for the majority of the time due to solar gain, or if AC will be preferred).
- Understanding if window orientation towards major sources of noise or pollution has a significant impact on window use.
- Understanding the real or perceived effects of dust, pollen, or particulate infiltration and window use.

2.4.5 Building Floor Height

By understanding the relationship between operable windows and the building floor height in which they are situated, architects may be able to choose the types of windows that address security issues and human psychological comfort. Related to window orientation, an understanding of the building neighborhood or site may assist in the design decisions that can encourage window use.

Within the body of research reviewed, vertical distance between office occupants and a source of annoyance (noise) generated at street level was shown to have an inverse relationship: the greater the distance, the lower the decibel level and potential for annoyance (Ghiaus et al. 2006; Nicol & Wilson 2004).

Prior to collecting data for this thesis, casual discussions were held with occupants whose office spaces had direct access to a terrace indicated some concern regarding security issues related to people entering, listening, or reaching through open windows (Ecotrust building visit, Portland, OR, 2008). Outcomes could initiate discussions among architects as to whether exterior solutions near or on windows can be implemented to provide security, but still allow for window utilization.

The design implications of research in this area may assist in:

- Understanding the degree to which personal, property and information security plays in the determination of window utilization.
- Understanding the comfort range of building occupants with respect to their distance from the ground.
- Understanding if effects of noise and particulates generated at ground level might be lessened with more vertical separation.

2.5 Summary of Research Significance

This chapter has described compelling evidence in favor of operable windows and natural ventilation in the office environment: energy efficiency, lower environmental impact, and economic gains. Health benefits from natural ventilation are indicated in a number of studies, and worker satisfaction and perceived increased work performance have been attributed to personal control of operable windows.

Studies by Milne 1995; and Baker and Standeven 1996 (as cited in Brager, et al. 2004) summarize the inter-relatedness of the areas covered in Chapter II:

> A greater understanding of the influence of personal control has implications for building design, occupant comfort, and energy use. If people remain comfortable in a wider range of conditions in naturally ventilated buildings that provide personal control, significant energy can be saved by relaxing thermal comfort standards and allowing more variable indoor temperatures that cycle or drift in response to the natural swing of the outdoor and indoor climate.

Understanding the relationship of personal control and operable windows by viewing it through the lens of the designed attributes of operable windows becomes the focus of this thesis.

CHAPTER III

RESEARCH DESIGN

"Everything that can be counted does not necessarily count;
Everything that counts cannot necessarily be counted."
(Albert Einstein)

The previous chapter indicates that there has been research conducted relating to personal control of operable windows in an office environment. By viewing personal control through the filter of designed attributes related to operable windows, new information has the potential to benefit designers and architects of office buildings. It was essential to design research methods that approached the investigation from a number of directions – from the qualitative human behavioral aspects, and from the quantitative survey of a sampling of occupants. This triangulation of methodologies was designed to allow each to inform and support each other. Figure 3.1 visually illustrates the Mixed Method of the research design.

3.1 Qualitative Methodology: Case Study Design

Comparative case studies of three office environments provide a critical focus for this research. When trying to understand environmental behavior, physical trace observations, informal interviews, field notes and photography were paramount in revealing the users' actual engagement with the operable windows in their office spaces. The beauty of the qualitative approach is the richness of information that can be revealed, and that the focus takes place in the occupant's natural setting – the "real world" (Leedy, 2005, pg 133). The three different case study offices offered both similarities and differences as revealed in research results discussed in Chapter IV.

3.2 Quantitative Methodology: Survey Design

The survey instrument was a web-based questionnaire built on principles outlined in Leedy and Ormrod (2005) and Dillman (2000). It was designed to address the operable window attributes outlined in this thesis, with questions relating not only to those things that could be measured (proximity of desk to window or type of window), but also the users' personal perceptions of how these aspects influenced their ability to control the windows.
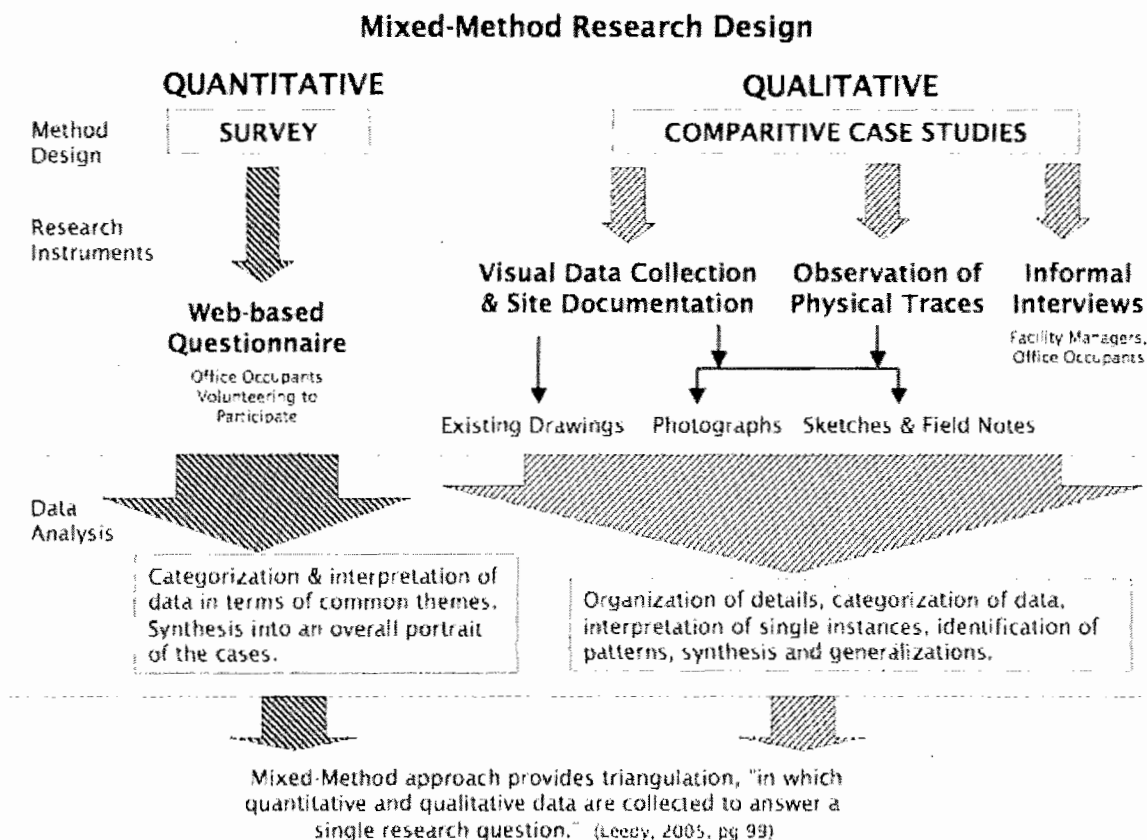
Figure 3.1 Triangulation of Research Methods and Instruments

3.3 Operationalization

Exploratory in nature, this research set out to uncover patterns and parallels from which to draw conclusions, and to discover areas worthy of further investigation. Human perception regarding personal control of operable windows was defined within the limits of a set of five variables: (1) Operational method of the windows, (2) Proximity of occupants to windows, (3) Accessibility of windows, (4) Orientation of windows, and (5) Vertical distance of window from ground level.

Through these five variables, both quantitative and empirical information was gathered. Ultimately, the information obtained was used as measurable indicators of whether or not certain design attributes would either encourage or discourage an office occupant to use the window. This provided the basis for how human perception of personal control was gauged. The assumed relation of personal control and these five attributes is simple: Less effort (physical, psychological) = Greater likelihood of window use.

3.3.1 Scales and Measures

Through the five established controlled variables, the perceived degree of personal control of operable windows was determined through participant response to a questionnaire. The majority of questions were based on a Likert-Scale (Leedy, 2005) and measured in relationship to empirical information collected through observation of physical traces and informal interviews. Independent variables, such as measurements, window locations, operation, and other issues, were also used to interpret the responses.

3.3.2 Research Questions

The questions addressed in this research were:

1. What are the design attributes of operable windows that allow them to be used by office occupants for controlling thermal comfort and natural ventilation?

a. What window design attributes have the greatest effect on occupants' perception of personal control of natural ventilation through windows?

b. What design attributes have minimal or minor effect on occupants' use of windows and perception of personal control?

c. What are the benefits and limitations of operable windows as cited by office occupants?

3.3.3 Pre-Research Visits

An initial "scoping out" of offices with operable windows was conducted in downtown Portland, Oregon, in late May. Buildings selected had both achieved LEED Gold[11] certification, and had incorporated operable windows as part of their natural ventilation and cooling strategies. Information was recorded through notes, sketches and photography, focusing specifically on signs of occupant use of operable windows. If someone appeared to be open to conversation, brief, casual discussions about window use were conducted with the goal of informing a more specific focus to the research yet to come. This step was instrumental in either defining, or verifying the variables that would be significant to the outcome.

3.4 Case Study/Survey Participants

While Minnesota may not come to the forefront when considering a setting to research operable windows, the potential exists, especially during the transition periods of spring and autumn (Appendix A – Minneapolis climate data). Inquiries went out to leading green architects active in AIA and USGBC[12] chapters in Minneapolis and Northern Minnesota, several leading firms in the state, and researchers at the University of Minnesota's Center for Sustainable Design. Three sites fitting the parameters (Section 3.4.1) were located, all of

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[11] LEED Gold – LEED certification ratings are based upon a point accumulation system, listed in the order of minimum to the maximum point accumulation: Certified, Silver, Gold, Platinum

[12] USGBC: U.S. Green Building Council, founder and regulator of LEED Guidelines.

which happened to be designed or renovated by the same architectural firm, LHB Engineers and Architects. The three settings proved to work well to conduct both the qualitative and quantitative methods of research outlined in this thesis. As will be discussed in depth later, research revealed a strong desire for Minnesotans to have operable windows for the fresh air benefits, even more than for passive cooling.

3.4.1 Participant Parameters

As part of the criteria established as control variables, case studies chosen share the following attributes:

- LEED or non-LEED buildings designed to utilize operable windows
- Office buildings that allow for occupant control of the operable windows
- Office buildings that are 6 stories or less
- Primarily open-office plan (questionnaires inquired of proximity to window, and level of control over operable window)
- Urban buildings (with surrounding neighborhood details addressed)
- Located in Minneapolis, Minnesota's metropolitan area, for consistency in climate and cultural attitude towards operable windows
- Operable windows open directly to the outside (no double skin façade, atrium, etc)
- Similar office culture and attitude
- Similar office hierarchy structures

As discussed in Chapter II, previous research has focused on some of the urban aspects as described above (Loupa et al. 2007; Germano 2006; Ghiaus et al. 2006). While all sites are in an urban setting, independent variables include such things as surrounding neighborhoods and window orientation. These aspects served to reveal the degree to which urban noise or pollution play in occupants' perception of personal control.

Two of the selected buildings had been designed using some form of environmental/energy guideline system available at the time (LEED certified, or pre-LEED), and had incorporated user-operated operable windows as part of the cooling/ventilation system in the buildings. One building was built as a warehouse/storage building in the late 1800s, later renovated into office spaces maintaining original operable windows as part of a set of "greening" techniques.

The buildings were not exclusively office "buildings," but each office space is clearly separated from other building uses such as warehouse or gallery spaces. Each setting is further described below, with a complete case-study matrix located in the Appendix A.

The Phillips Eco Enterprise Center (aka PEEC)

- Built in 1998, LEED NC[13] pilot project[14]

- Occupants: The Green Institute offices (non profit environmental/ community based organization)

- Number of employees: 12

- Floor occupied: first (ground floor) of 2-story building

Figure 3.2
Phillips Eco Enterprise Center,
Minneapolis, Minnesota

- Surrounding Context: Warehouse/commercial/ industrial corridor just southeast of downtown Minneapolis

- Window Operational Method: Awning on bottom third of all windows

Figure 3.3
Green Institute awning
windows and office space,
Phillips Eco Enterprise Center

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[13] LEED NC – LEED New Construction, one of several categories of LEED certification according to project typology.

[14] Pilot Project – Project initiating LEED guidelines during first stages of LEED development.

The Traffic Zone Visual Center for the Arts

- Built in 1886, renovated in 1995, prior to LEED, but with environmental strategies incorporated. National Register for Historic Places.

- Occupants: LHB Engineers and Architects offices

- Number of employees: approximately 45

- Floors occupied: fourth floor and sixth floor of 6-story building

Figure 3.4 Traffic Zone Visual Center for the Arts

- Surrounding Context: Downtown Minneapolis Warehouse District, medium to heavy traffic nearby, building oriented 45 degrees off cardinal directions.

- Window Operational Method: Large, original 1886 double hung windows.

Figure 3.5 Offices of LHB, Traffic Zone Visual Center for the Arts Building

Quality Bicycle Products

- Built in 2005, LEED NC Gold

- Occupants: Quality Bicycle Products distribution center and administrative offices. Research focus limited to open office spaces

- Number of employees: approximately 70

Figure 3.6   Quality Bicycle Products, Bloomington

- Floors occupied: second floor of 2-story building

- Surrounding context: Suburban location in Bloomington, a suburb just south of Minneapolis

- Window Operational Method: Awning windows in conjunction with fixed and spandrel to form glass wall

Figure 3.7
Quality Bicycle Products,
south windows

Figure 3.8
Quality Bicycle Products,
north windows

3.5 Incorporation of Research Instruments

After deliberation of what research methods would be most beneficial to this thesis, and because of unforeseen scheduling issues (namely, one cannot count on observing operable window use in Minnesota in late autumn), research instruments had to be carefully chosen to provide meaningful information. The variety of tools implemented offered a triangulation of quantitative and qualitative data. Input of the occupants of offices themselves was also imperative – as this thesis specifically addresses their perceptions.

3.5.1 Ethical & Professional Considerations

It was important, when dealing with people in their work environment, that this research be conducted in a respectful manner. Observation of physical traces is, by its nature, an unobtrusive instrument for gaining valuable information. Yet even if there is no direct contact or conversation with the occupants, the presence of a researcher in an office admittedly could be perceived as interference. Great care was taken to remain inconspicuous and professional. To be respectful of the participants' time, the questionnaire was designed to be completed in approximately fifteen minutes. It was reviewed and approved by the Office for the Protection of Human Subjects at the University of Oregon to ensure it met their moral and ethical standards for research.

3.5.2 Site Visits

Basic site information was gathered at two different time periods (summer and autumn) to establish the base for the case studies, and to assist with fine-tuning and later analysis of the questionnaire. Because there was to be no "real time" human behavioral observation, and no relationship established between interior and exterior climatic conditions, there was no need to document temperature, relative humidity, or wind; however, major sources of outdoor traffic noise were noted, to assist in analyzing window orientation.

3.5.3 Data Collection

Initially, site information was collected to aid in setting up the questions for investigation, as described by Zeisel (2006, pg 168). Physical measurements, sketches, drawings, field notes and photographs of the items on the following list were gathered either at the site visits, or obtained shortly afterwards:

Site Information
- Orientation and footprint
- Floorplans and office layouts
- Surrounding structures and neighborhood
- Traffic patterns/noise
- Sun access
- Vegetation of surrounding site
- Local climate data

Physical proximity of occupants to operable windows
- Distance between occupants (desk layout) and windows
- Immediate, personal control at work station
- Separation, if any, from window by other work station(s)
- Separation, if any, from window by circulation or shared open space

Window Position on the Outside of Building
- Floor level as measured from ground level outside of building

Window Position on the Inside of Building
- Height from floor

Window Accessibility and Operation
- Window operational method (double-hung, casement, awning)
- Window hardware
- Accessibility of window related to obstructions
- Ease of window operation

Window orientation
- In regards to sun and solar gain potential
- In regards to outside influences of noise, pollution

3.5.4 Observation of Physical Traces

Recent data supports the idea that observation of physical traces can be used as a stand-alone method, equal in weight and value to methods such as questionnaires (Zeisel 2006). Physical trace information collected at one site in

particular was quite revealing of window use and non-use by occupants; however, for the research to embody an outcome that was richer, physical trace observation was combined with other research instruments, such as the questionnaire.

Speculation on evidence of window use/non-use that could potentially be found were such things as the amount of clutter on window sills or next to windows, objects blocking operable portion of windows, accessibility of handles or operating mechanisms for windows, position of blinds or shades, use of paperweights, and signage. With such environmental behavior observations, openness to the unexpected can also be revealing. Through photography, sketches and field notes, the physical traces were documented, and will be discussed further in Chapter IV.

> *"From such traces designers and environment-behavior researchers begin to infer how an environment got to be the way it is, what decisions its designers and builders made about the place, how people actually use it, how they feel about their surroundings, and generally how that particular environment meets the needs of its users."*
> *(Zeisel, 2006, pg 159).*

3.5.5 Informal Interviews

Informal interviews were conducted in situations where individuals looked receptive to visiting, or otherwise initiated a conversation. While the informality of such interviews prohibits a strict format of questions, the following list was reviewed and approved by the Office for the Protection of Human Subjects:

- I see you have your window open today. Do you use the operable window often?
- When do you open your window?
- Do you have sole access to it, or do you share window responsibilities with others in the office?
- What do you do when another person close to the window has a different need than you for either opening/closing the window?

Questions similar to these were asked of both office occupants seated at their desks, and also of those in charge of office facilities. The researcher noted

discussions immediately after leaving the office so as not to disturb the occupants, and to maintain a friendly, casual air while visiting the settings.

3.5.6 Web-based Questionnaire

The questionnaire was based on principles outlined in Leedy and Ormrod (2005) and Dillman (2000), and also on questionnaire format and distribution used in previous research (Kwok, Coltrane-Briscoe, & Meier 2008; Zagreus et al. 2004). Questions were related to occupant observation, description, opinion and perception, and were designed to cover the five design attributes categories of operable windows as outlined in Chapter II.

Once the questionnaire was reviewed and edited several times with assistance from the thesis advisor and committee, it was submitted for review and approval to the Office for the Protection of Human Subjects. With their approval, the questionnaire was then given a pilot test distributed to architecture faculty at North Dakota State University. The pilot test produced several suggestions for minor edits and clarification. The questionnaire was then placed into the internet-based software, SurveyMonkey.com (Appendix B).

Prior to distribution, contacts at all three sites had indicated a willingness of their offices to participate in the voluntary web-based survey. For distribution, the survey link was embedded in an email sent to these contacts (office managers or the environmental coordinator), who then forwarded the email to all employees working in the office spaces within their buildings. Questionnaires were accessible through the web-link, and could be discarded, or taken on a voluntary basis. Completion and submission of the survey constituted their consent, though the results were anonymous. Participation was approximately 30% of those receiving the email request. Email correspondence to participants is included in the Appendix of this document (Appendix B).

3.6 Research Follow-up

A couple weeks after the distribution of the questionnaire, a token of appreciation (boxes of locally made chocolate), as well as a thank-you card that included the questionnaire link was sent to all sites (Appendix B).

3.7 Summary of Research Methodology

Results of the research methodology were analyzed and will be discussed in detail in the next chapter, revealing the designed attributes of operable windows that have an effect on occupants' perception of personal control, or the degree to which that is or is not true.

CHAPTER IV

FINDINGS AND DATA ANALYSIS

Through the research methodologies described in the previous chapter, the collected data is analyzed on the following pages. Findings are categorized according to the Design Attributes of Operable Windows introduced earlier, with both the qualitative and quantitative data disseminated. The final section of this chapter provides information of a more general nature related to operable windows and personal control. While it was not a focus of the research questions, it revealed some interesting results.

4.1 Analytical Framework

Methodologies used to gather information included informal interviews with office occupants, observation of physical traces, and physical measurements of the built environment pertaining to the area of study. A significant piece of the methodology was the web-based survey. The 37 responses represented a 30% sampling of those who could voluntarily take the survey from the three sites. The questionnaire gathered information pertaining specifically to the Design Attributes of Windows, with some crossover occurring in each section, to correlate various aspects and consistency in the answers given. The breakdown of data collected through the various methods is illustrated in Table 4.1:

Design Attribute	Survey Questions	Informal Interviews	Observation & Physical Traces	Measurements & Documentation
Operational Method	12, 13, 14, 15, 16 (9)	x	x	x
Proximity	4, 5, 6, 7, 8 (2,3)	x	x	x
Accessibility	11, 12, 13, 14, 15,16		x	x
Orientation	17, 18 (9, 11)	x	x	x
Floor Height	9, 10 (17, 18)	x		x
General Info	1, 2, 3, 19, 20 (open-ended)	x		

Table 4.1   Research Instruments

While no identification of site was specifically asked for within the questionnaire, conveniently, each office occupies a different floor of a building, allowing for the data to be coded according to what floor the respondent occupied (#9 on the questionnaire). For the purpose of this study, the individual offices will be referred to as Office 1, 2 & 3, as described in Table 4.2. More detailed information of each site is given in Chapter 3, as well as in the site matrix, located in Appendix A.

Reference	Floor Occupied	Building	Tenant
Office 1	1st	Phillips Eco Enterprise Center	Green Institute
Office 2	2nd	Quality Bicycle Products	QBP Administrative Offices and Distribution Center
Office 3	4th & 6th	Traffic Zone Visual Center for the Arts	LHB Engineers and Architects

Table 4.2 Site Reference Summary

For consistency, the results of the survey findings will be addressed first, with additional data from the other research instruments following in support of or in contrast to questionnaire results.

4.1.1 Operational Method of Windows

Directly related to decisions that architects make regarding operable windows, the method of operation applies to the window size and type, and affects window design and facility maintenance issues. This area was covered by all of the research methodologies, with information gathered through informal conversations with occupants, through measurements, sketches, photos, and survey questions.

The windows of the three sites researched had differences in operational method, handles, and age and condition of windows, resulting in a rich collection of information gathered. Survey questions pertaining to the operation method of windows were as follows:

SURVEY QUESTION:
Are the operable windows in your office too high from the floor, too low to the floor, or about the right distance from the floor for letting people use them?

This question pertains to the ease of window use related to the method of operation of the window. For example, if a window can be opened with a lever or crank at a comfortable height from the floor, then the vertical position of the window itself is not an issue. In this case, Office 3 has large, 100+ year-old double hung windows, some of which have handles only 18" from the floor.

Considering the weight and age of those windows, along with a position that would require the user to bend over to open

Figure 4.1 Office 3: Low window with handle and sill located approximately18" from the floor. An employee stands next to the window for scale.

them, there is potential difficulty in their use. This was verified when, of the four responses indicating the windows as being too low, three of them were from Office 3 (Figure 4.1).

One response of "too low" came from an occupant of Office 1, where the window hardware is 36" from the floor. Other responses indicated no significant problems with height from the floor. Office 2 has window handles at either 41" from the floor, or 53" from the floor, depending on the windows.

SURVEY QUESTIONS:
Does the handle, lever, or crank on the window make the window easy to use, or difficult to use? (Figure 4.2)

Does the handle, lever, or crank on the window ever affect the decision to open a window?

Figures 4.2   Operational Method: Handle or Lever
(question 13 correlated with 9)

Degree of Ease
of Use

Floor Occupied
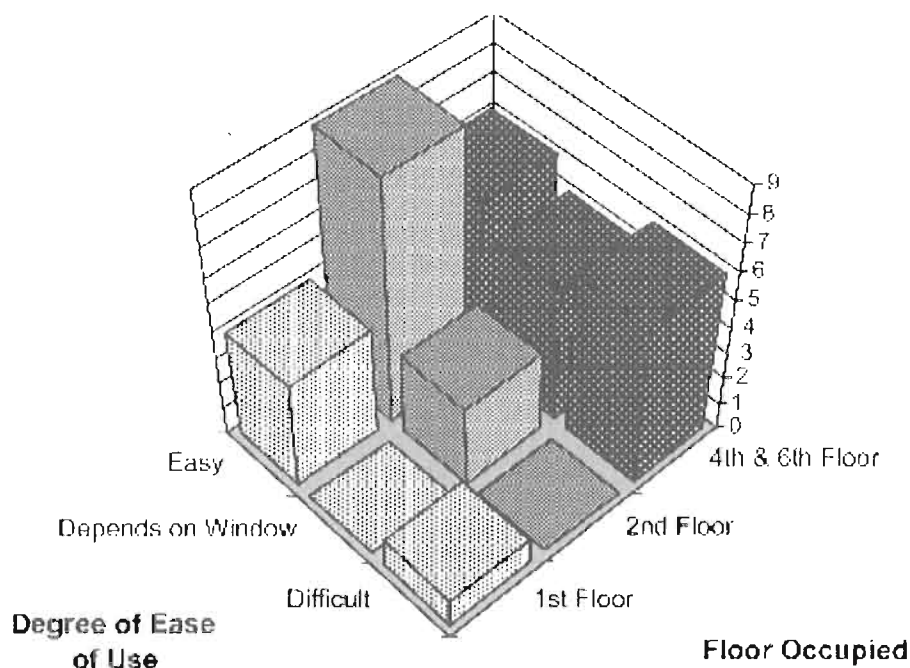
The three sites had a variety of handles or levers for opening/closing the windows. Older windows with their original metal handles (or recessed groove within the frame) might make window operation somewhat more difficult. Again, 6 out of 7 responses indicating a difficulty with the handle were from Office 3, with the older windows. As a follow up question, of whether or not that determined their decision to use the window, the most frequent response was "sometimes."

Figure 4.3   Office 3: Handle from original 1886 double-hung window with metal handle.

Figure 4.4   Office 3: Handle on 6th floor retrofitted double-hung, double-glazed awning window.

At the same time, Office 3 also had as many responses indicating "easy to use" relating to the handle, and nearly as many stating it "depends on the handle." While a few employees in Office 3 are located on the sixth floor, where the original windows and handles have been replaced (See Figure 4.4), some of the 100-year-old windows on the fourth floor had been repaired and worked quite well when tested during the site visit.

Figure 4.5
Office 2: Crank mechanism on awning window had highest reports of "easy to use" when referring to the crank.

Figure 4.6
Office 1: Lever mechanism on awning window also had mostly positive reports.

In both Office 1 and 2, the prevalent response to window use relating to the handle was "easy to use," as seen in Figure 4.2.

SURVEY QUESTIONS:
How easily does the window nearest you open (how it glides in the track, or
swings open)? (Figure 4.7)

Does the ease or difficulty in the window's movement (opening and closing) affect
whether or not the window nearest you gets used?

While Office 1 and 2 both have awning windows that are approximately
10 years old or newer, Office 3's original 1886 double-hung windows still
maintain the rope-and-weight pulley system. This is in part due to the fact that
the building is listed on the National Historic Register, with necessary efforts to
maintain as much of the original character of the building as possible.

Again, it was speculated that these windows might be more difficult to
open, due to age and size. While the majority of the responses of "difficult" or
"very difficult" from all three sites were again from occupants in Office 3 (8 out
of 9), Office 3 also had a similar representation of windows that opened easily or
somewhat easily, as noted on Figure 4.7. Again, the majority of follow-up
responses pertaining to the movement of the window as a determinant to
window use was "sometimes."

Figure 4.7   Operational Method: Movement of Window
               (question 15 correlated with 9)

Floor Occupied

Degree of Window Movement
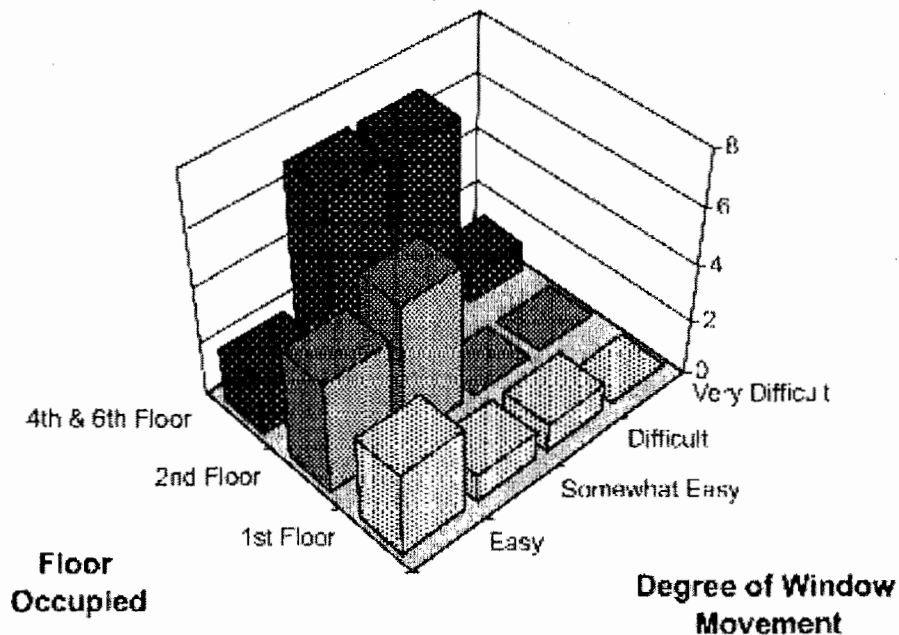
Informal conversations with employees at Office 3 revealed further support of the survey findings:

> One employee mentioned that the large window near her is difficult to open. She likes it open, so has to have guy next to her help her open it.

> Another window in Office 3 was referred to as *"a two-person window"* – speaking of how heavy/difficult it is to open

The open-ended survey question dealing with suggested improvements for window design also revealed an issue with weight of windows:

> *"Our windows are very heavy (it's an older building) and opening them can be difficult, but I like having the option and we frequently open them."*

> *"Windows that only require one hand to open"*

Observation from the site visits revealed window use by the "props" laying on the windows, especially in Office 3. While the survey pertained to the stiffness of window movement, the older windows also were not always tight in their track. Blocking and bracing for keeping the double hung windows open was found as evidenced through wooden braces and bricks placed in windowsills (Figures 4.8 and 4.9).

Figure 4.8 (left) and 4.9 (right)
Office 3: Props to hold double-hung windows open at different heights reveals use but may indicate that the windows no longer hold themselves open.

4.1.2 Physical Proximity of Occupants to Windows

Because proximity is a designed intention, not only for placement of desks/cubicles, but even as a determinant of floor plate width, it was important to include this attribute in the research. As discussed in Chapter II, previous research has also shown a link to occupant preference of sitting near windows, for benefits of natural light, views, ventilation and personal control (Yildirim et al. 2007; Mahdavi & Unzeitig 2005; Zagreus et al. 2004; Baskaya & Eken 2003). The findings in this study pertained to backing up the hypothesis that the nearer one sits to a window, the greater the chance that they will open the window themselves. A number of questions revealed answers that supported this. (See survey questions and Figure 4.10.)

SURVEY QUESTIONS:
When the weather is conducive to using the windows, how often are the operable windows NEAREST YOU opened? (those windows nearest your personal workspace)

Which of these situations best describes the distance you sit from an operable window within your work place?
Work area 0-10 feet from an operable window
Work area 11-20 feet from an operable window
Work area 21-30 feet from an operable window
Work area greater than 30 feet from an operable window

Does the distance that you sit from the window determine whether or not you open or close the window?

From the number of respondents sitting within 10 feet of the windows, the survey revealed that the window nearest them was open more frequently than with those sitting further from the window. Of that sample, a majority agreed that the distance they sat from the window determined the window use. (Figure 4.10) These results indicate that proximity to windows is an important factor in window use.

Figure 4.10   Proximity as a Determinant of Window Use
(questions 2, 4 & 5)
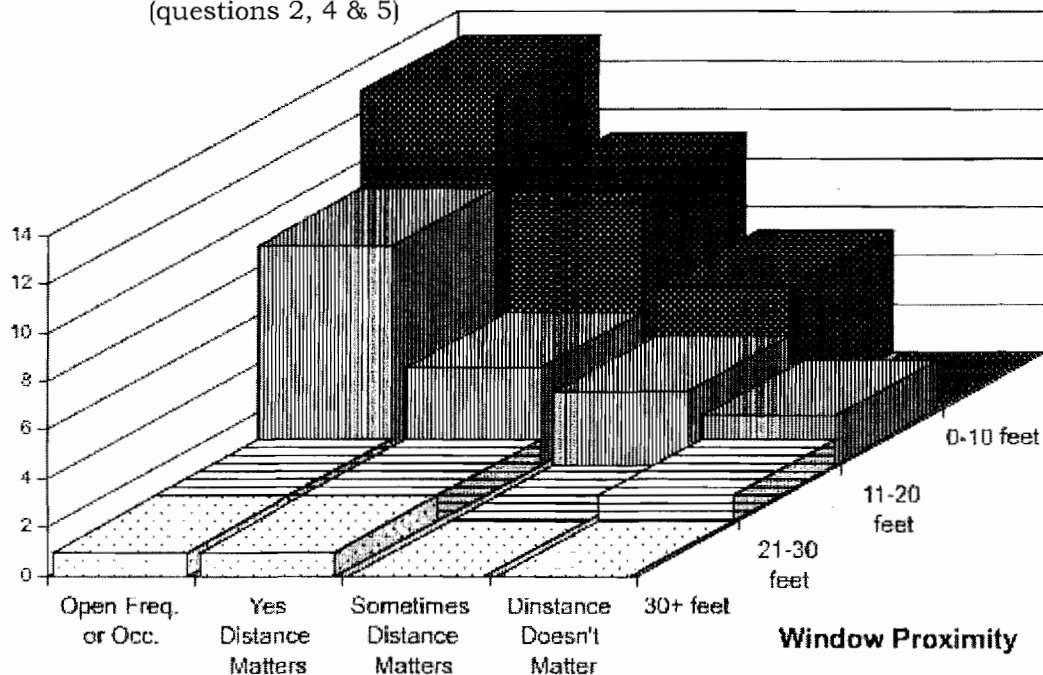
Taking the question further, office occupants were asked who was in control of the window nearest them. Of the 15 respondents sitting within 10 feet of the window, 10 opened the windows themselves, and 3 more shared the duty with a coworker. Only 3 of those people closest to the window let others open the windows. This information was correlated with occupants' view of the importance of personal control of windows, again revealing a relationship with proximity to the windows and the importance placed on personal control of those windows. (See survey questions and Figure 4.11.)

SURVEY QUESTIONS:
If there is an operable window near you, who is most likely to open or close it?
Yourself
Coworker who sits closer to the window
Coworker who prefers to use the windows more than you do
Designated employee or management
No one opens the operable window closest to you

How important is it to be able to control the operable windows yourself?

Figure 4.11   Proximity, Personal Control and Frequency of Use
              (questions 2, 4, 8 & 20)
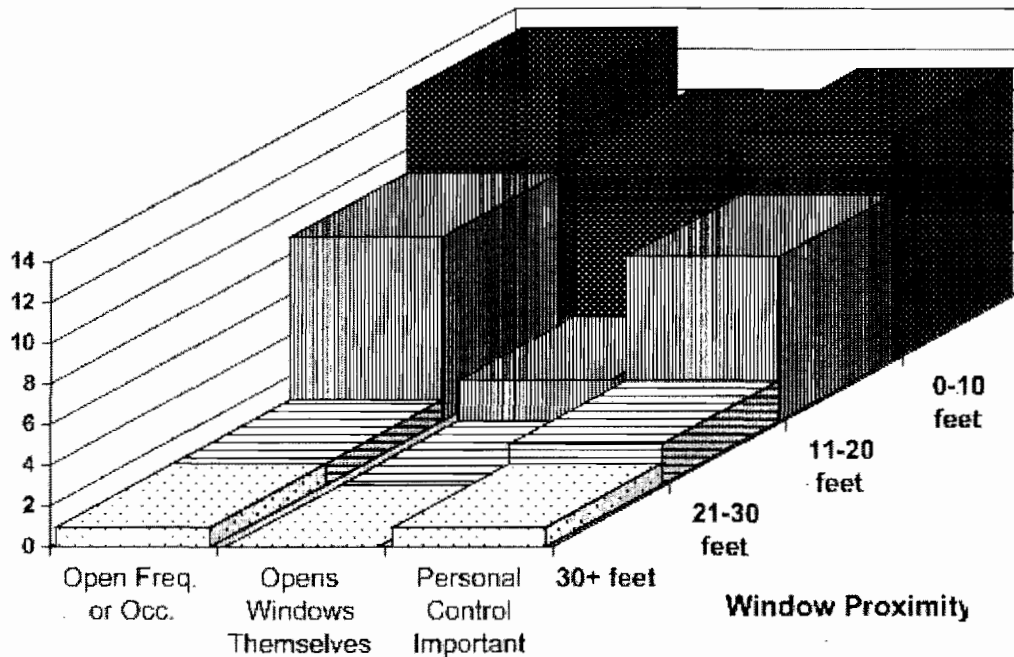
As a design attribute, proximity also included the *relationship* of the workspace (desk) to the windows. This included what, if anything, was between the office occupant and the windows, and if that was a determinant of window use and personal control. The questionnaire addressed relationship with these queries (shown in abbreviated form) and is illustrated in Figures 4.12 and 4.13.

SURVEY QUESTIONS:

Which of these situations best describes the relationship of your workspace (cubicle, desk) to the operable window(s)?
        There is nothing between the window and my work area
        There is a walkway, corridor, or shared general workspace
        There is another employee workspace
        There are several employee workspaces

Does the relationship of your workspace to the window determine whether or not you open or close the window? (select the one that is most frequently the case)

When the weather is conducive to using the windows, how often are the operable windows NEAREST YOU opened?

If there is an operable window near you, who is most likely to open or close it?

Figure 4.12   Desk Relationship as Determinant of Who Opens Window
(questions 2,6, & 8)
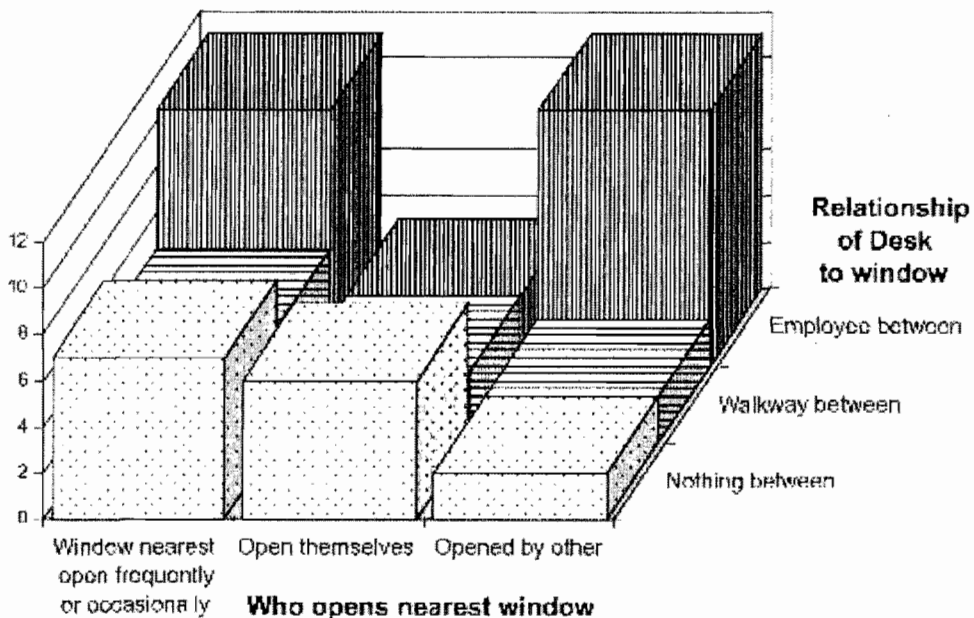
Figure 4.13   Desk Relationship as Determinant of Window Use
(questions 2,6 & 7)
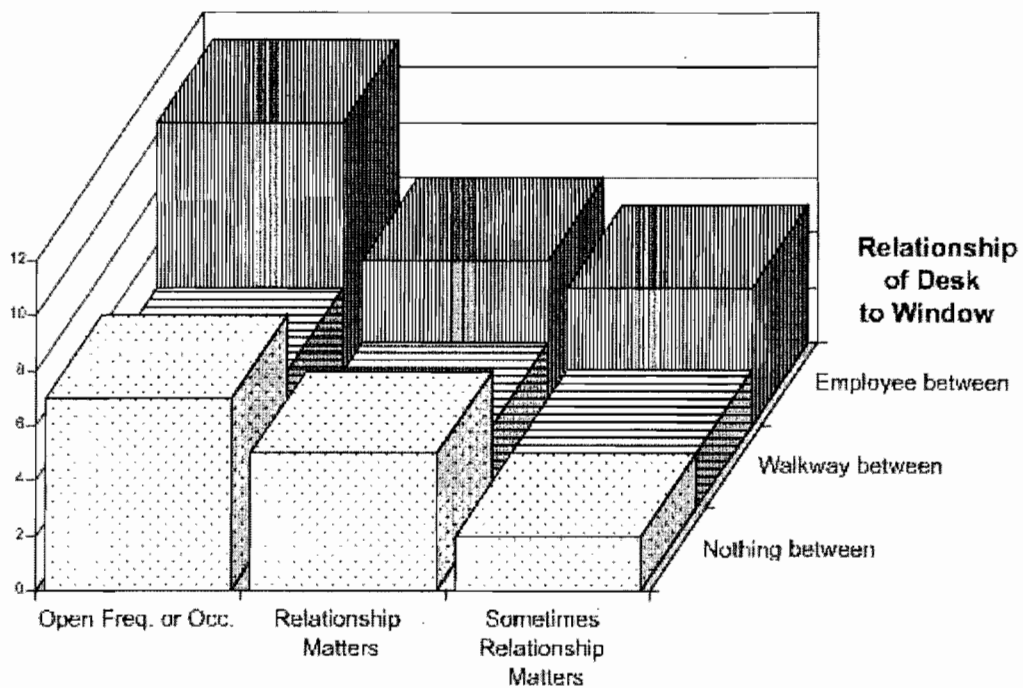
When the questions pertaining to workspace relationship and windows were correlated with the questions of how frequently the window nearest respondents was open, or who was the most likely to open the window, it was again apparent that proximity to windows is a factor in who will open windows (Figure 4.12).

The relationship of one's desk to the window makes a difference as to whether or not the employee will open or close the window, according to the survey. There is a greater likelihood that the person sitting closest to the window will use the window, whether it is the respondent themselves or another employee who sits closer (Figure 4.13).

Floor plans and general layout of workspaces were noted and sketched during the site visits. (Floor plans of Office 2 and Office 3 can be found in the Appendix A.) In all three sites, there were varying degrees of proximity and workspace relationship among employees and windows. Table 4.3 indicates:

Reference	Min. Distance	Desk Relationship	Intermediate Distance	Max. Distance
Office 1	3 feet	Can be next to window	10 feet	11 feet +
Office 2	8 feet	Minimum of a walkway between	14 -22 feet	60 feet
Office 3	4-5 feet	Can be next to window	8-10 feet	15 feet +

Table 4.3 Office Site Summary of Proximity and Desk Relationship

Office 1 had the narrowest footprint, with no more than 2 workspaces of depth from the window wall, although a few desks were next to non-operable windows that were on the same façade as the operable ones. Office 2 had the widest footprint (floor plate), with some employees sitting as much as 60 feet from the windows. Office 2 also had walkways between window walls and cubicles, so no employees were immediately next to a window. Office 3 had three varying relationships between workspaces and windows. Out of three different orientations (NW, SW, and SE) two sides of the office had employee workstations immediately next to windows, while one side had employee workstations separated from the window wall with a walkway. Refer to figures 4.14 through 4.18.

Figure 4.14 (left)
Office 1: Interior
A typical workspace, where one desk is close to the window, and another within the shared workspace (left, side, not in photo, is about 10 feet away.)

Figure 4.15 (right)
Office 2: North Interior
The walkway along the window wall (similar on the south wall.)

Figure 4.16 (below)
Office 2: South Interior
The hexagonal cubicles spread across the floor of the office, with occupant proximity to windows varying from about 8 feet to 60 feet.

Figure 4.17 (left)
Office 3: Interior with Walkway
The walkway is only on one of three sides of the office along the window wall. The other two orientations of window walls have desks immediately adjacent to the windows.

Figure 4.18 (below)
Office 3: Workspaces
The open workspaces allow for visual and thermal access to the windows.

4.1.3 Window Accessibility

Window accessibility refers to the ability to get near the windows, or to reach the mechanisms for control of the window. Clutter or objects in front of the windows, whether on the floor, the sill, or in front of the glass can have double meanings. Clutter may interfere with access to the window, rendering the operable window useless. Clutter or objects in front of the window might also indicate that the window was not being used; therefore, items accumulated in and around it (figures 4.19 & 4.20).

The following question was asked of the survey participants. For analysis, the information gathered was paired with what floor they occupied (refer to Table 4.2 earlier in this chapter), again revealing the differences between office sites. Results are illustrated in Figure 4.21.

Figure 4.19
Office 3: A fixed, inoperable window has become a place where furniture and other items have accumulated. This is in contrast to what the research was seeking to find – whether accumulation of items in front of windows prohibit their use.

SURVEY QUESTION:
Do the following affect the use of the operable window(s) in your vicinity?

> *Blinds or shades get in the way of opening the window*

> *Books, plants, or other objects on windowsills prevent use of the window*

> *Furniture or large objects on floor area in front of window prevent use of the window*

Survey results were in line with observation of physical traces at the sites. Books and furniture were not a huge issue, but of 7 people responding to either or both affecting use of windows, 6 people were from Office 3 (4th/6th floor), as seen on Figure 4.21.

Figure 4.20 Office 3: Used Window. Physical traces indicate that this window does get used, as evidenced by the wood and brick blocking to hold the window open. At the same time, there is some accumulation of items in front of the window, which could potentially hinder window use.

Figure 4.21   Accessibility to Windows
(question 11 correlated with 9)

Height of Window from Floor

Objects on floor

Objects on Sills

Blinds/Shades

Potential Obstructions

4th & 6th Floor

2nd Floor

1st Floor

Floor Occupied
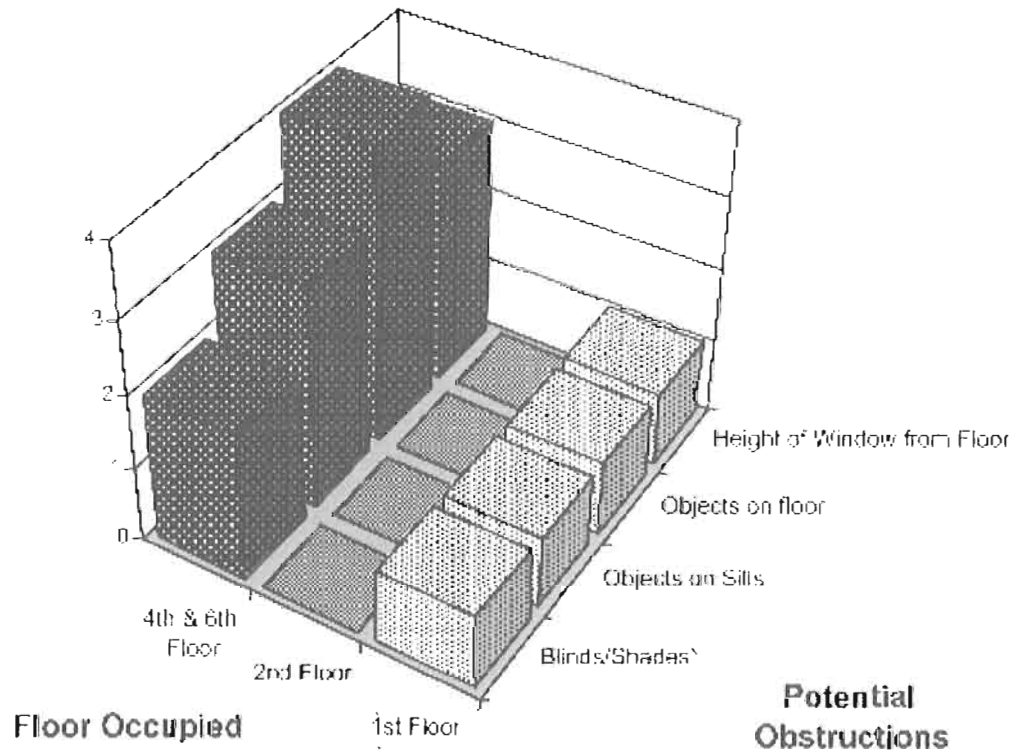
Office 2 (second floor) has windows that were very accessible as observed at the site visit. This was validated in the survey with no obstacles noted from Office 2 (Figure 4.22).

Office 1 had only one citation of potential obstacles affecting window accessibility. Again, observation of physical traces during the site visit at Office 1 revealed that most windows were clear of obstructions, but some had potential to deter window use (Figure 4.23).

When blinds and shades were noted as obstructions, they were cross checked with survey questions 17 and 18, pertaining to heat from solar gain, or glare. In each of the cases where blinds or shades were listed as obstructions, they were directly linked to issues of solar gain heat and glare.

Figure 4.22 Office 2 (above) window access

Figure 4.23 Office 1 (below) window access

For purposes of this research, accessibility could also refer to the ease of access to operable windows related to universal design[1] and ergonomics[2]. Survey questions dealing with these areas have already been addressed under "Operational Methods," and though the questions will again be listed here, the outcomes will not be repeated in this section. Please refer to the research results earlier in this chapter that relate to the flowing questions:

SURVEY QUESTIONS:
Are the operable windows in your office too high from the floor, too low to the floor, or about the right distance from the floor for letting people use them?

Does the handle, lever, or crank on the window make the window easier to use, or difficult to use?

Does the handle, lever, or crank on the window ever affect the decision to open a window?

How easily does the window nearest you open (how it glides in the track, or swings open)?

Does the ease or difficulty in the window's movement (opening and closing) affect whether or not the window nearest you gets used?
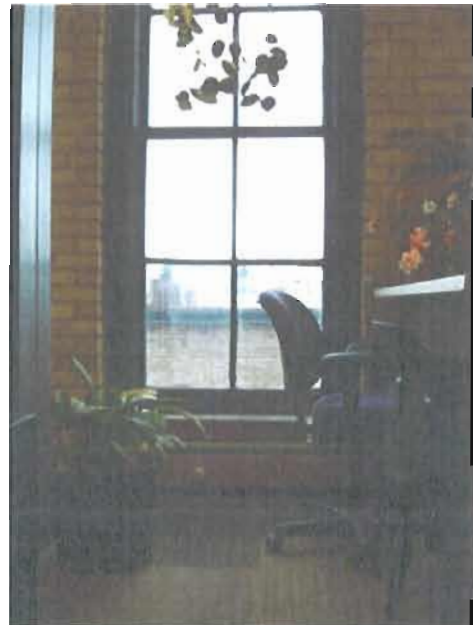
Figure 4.24
Office 3 window access:
An example of an
operable window used
frequently, free from
obstacles or clutter.

---

[1] Universal Design – dealing with accessibility issues that can be "universally experienced" by people with varying degrees of health, body function, etc.

[2] Ergonomics – dealing with ease and efficiency of human movement in their work environment.

4.1.4 Window Orientation

A clear understanding of the site and orientation is important when incorporating operable windows; not only for sun, wind, and light, but for views, vegetation, sound/noise sources, and potential pollution sources. As a design attribute, orientation was addressed with this research through the following questions listed on the survey:

SURVEY QUESTIONS:
Do any of the following conditions affect your sitting / working position at your desk?
  Heat from solar gain
  Noise through an open window
  Pollution, dust or pollen through an open window
  Glare from light through a window

Do any of the issues above affect your decision of whether or not the window nearest you gets used? (select all that apply)
  Heat from solar gain
  Noise through the open window
  Pollution, dust or pollen through the open window
  Glare from window

When conducting the informal interviews, it became apparent that not all office occupants knew exactly what direction the windows closest to them faced. In the case of Office 3, the building itself is about 45 degrees off the cardinal directions but within a gridded urban setting, making it confusing for those who expect orientation to be more clearly North, South, East or West. Because of this uncertainty, a survey question asking them to identify the orientation of the window closest to them was omitted from the questionnaire. Window orientation findings would have clearly been more revealing and substantive had that information been collected to compare with other responses.

Following is Figure 4.25, revealing the results of the questionnaire compared with the floor occupied (revealing the site). To assist in analysis, the number respondents from each site are also represented on the graph (far right columns), for a proportional comparison from each site.

Figure 4.25   Considerations of Window Orientation
              (questions 17 correlated with 9)
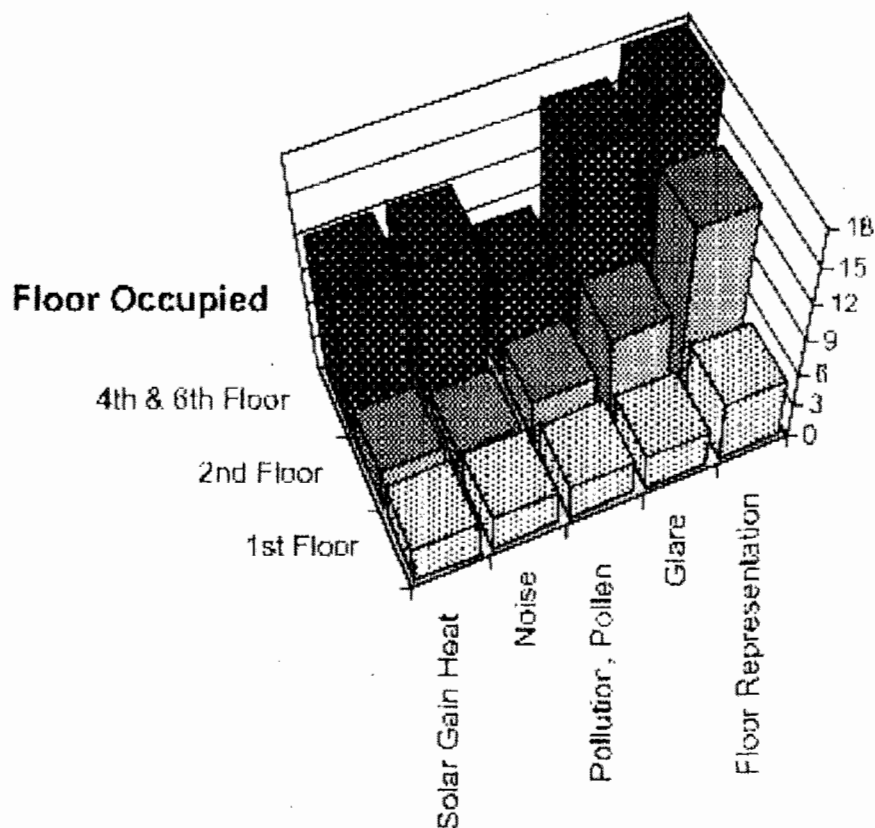
When considering responses proportional to the representation of occupants per floor (Figure 4.25), those on the second floor (Office 2) list fewer issues with the orientation factors than do the other floors represented. One half of those on the second floor are on the north side, and half on the south, yet have proportionally lower responses indicating heat and glare than do those from the first floor (Office 1). This seems curious, as the windows from the first floor office spaces all face north.

The second floor offices are also in a more suburban environment, which might explain fewer issues with noise or pollution. The second floor offices are also near a wildlife preserve, with heavy vegetation, yet that doesn't seem to translate into more pollen. The most urban environment is the office located on fourth and sixth floors – Office 3.

Of the survey responses that noise affects them either FREQUENTLY (2) or OCCASIONALLY (15), ten of those seventeen said it effects their decision to use the window. In the case of pollution affecting respondents at their desk either FREQUENTLY (2) or OCCASIONALLY (13), seven of fifteen said it affects their decision to use the window.

Informal interviews with occupants at Office 3 revealed the difference that orientation makes on the perception of noise:

> *An employee on the northwest side of the office made a comment about it being quiet compared to the southwest side when the windows were open, being the northwest side did not face the streets.*
>
> *In comparison, an employee on the southwest side of the office listed traffic noise, construction vehicles and sirens as issues of annoyance.*
>
> *Another employee commented on the noise from heavy traffic and dust being a problem on the southwest side of the office.*
>
> *The southeast side of the office solicited comments about noise from construction traffic passing by frequently, due to a new stadium being built down the street.*
>
> *Another person on the southeast side discussed the dust problem in the office, not sure if it was from the construction traffic, or from the ceiling of an old building.*

Glare and heat from solar gain were analyzed separately, to see if closer proximity elicited a higher level of sensitivity to either issue, as illustrated in Figure 4.27.

Figure 4.26   Office 3 window shades are a double system for better control of glare and heat on the southwestern side the office space.

Figure 4.27   Solar Gain and Glare Related to Proximity
               (questions 17 & 4)
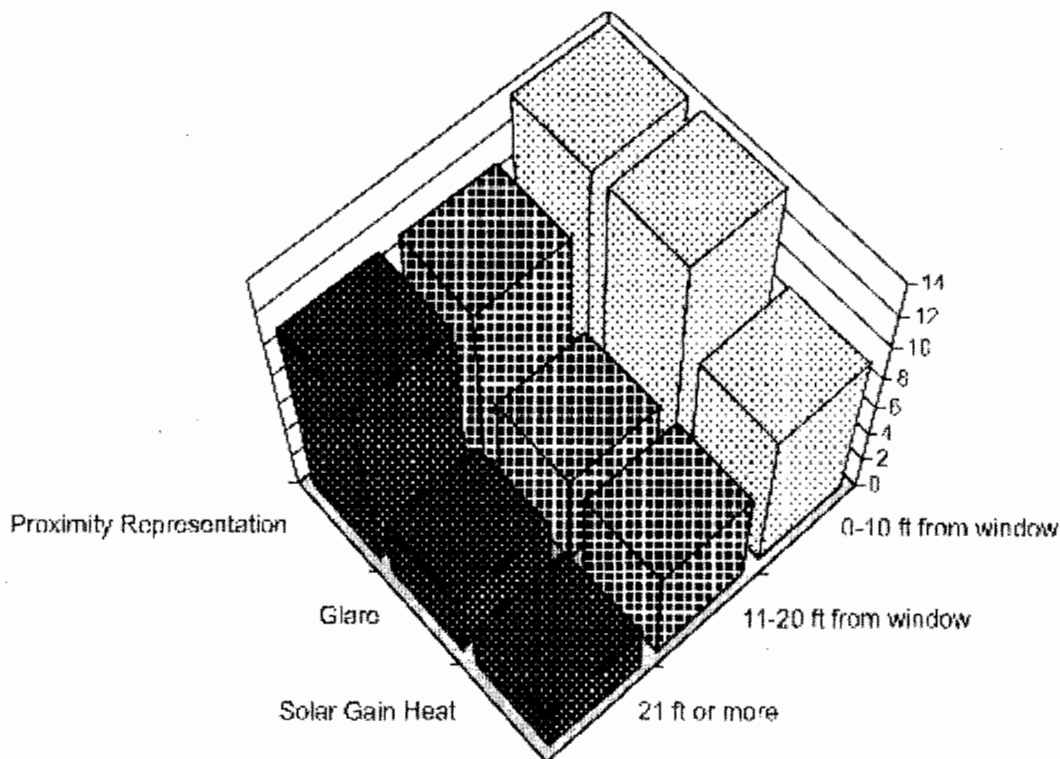
Proportional to proximity, glare is of greater issue to those sitting within 10 feet of a window than is heat from solar gain. Out of those stating that glare/solar gain is a frequent issue, 7 out of 10 have desks within 10 feet of a window. When the distance from the window increases to 11-20 feet, glare and heat even out, and at 21 feet or more from a window, their effect is reduced even more.

As mentioned earlier in this chapter under accessibility, there is a small but clear correlation with blinds or shades becoming an obstruction to window use when glare or heat from solar gain is also an issue. While this seems an obvious relationship, it indicates additional implications to window use/non use besides glare and heat. It indicates that windows are less likely to be used, if not properly protected from sun through some architectural design intention (and not just blinds). This will be discussed further in the next chapter.

Informal interviews with office occupants in Office 3 indicated a predictable reaction to orientation related to heat from solar gain and glare. On the northwest side of the office, only mesh shades were used on occasion, as solar gain was not an issue, according to the office manager. The Southwest windows needed double shades, (figure 4.26) and comments from several employees were made about the hot afternoon sun, and the glare. The windows were still used, however, according to one comment:

> *"We have the windows open a lot. It really bakes in this corner in the late afternoon"*

Site visits also revealed the reasons people love windows – a connection to the outdoors and views, and the ability to sit in the sun (especially in a cold climate). Office 2 has two distinct orientations that their office employees relate to – a north side and a south side. The south side seemed to reveal traces of habitation related to taking advantage of light and warmth from the sun (Figures 4.28 and 4.29).

Figure 4.28 (above) and Figure 4.29 (below) Office 2: Two views of the south side.

The north facing window wall of Office 2 was all about the view – a nature preserve within the suburb (Figure 4.30), ablaze with fall colors at the time of the site visit.

Figure 4.30
Office 2: North side facing Hyland Lake Park Preserve in
the midst of a Minneapolis suburb.

4.1.5 Building Floor Height

Recognizing the relationship between operable windows and the building floor height in which they are situated, architects can choose the types of windows that address human security and psychological comfort. Issues of noise, pollution, pollen, dust, insects or birds entering through open windows can also be addressed and dealt with in a number of ways. Related to window orientation, an understanding of the building neighborhood or site may assist in the design decisions that can encourage window use.

The design attribute of building floor height was addressed in the survey through a number of questions, some based on comments elicited from prior site visit observations. The most direct question pertaining to floor height

-What floor level is your personal office workspace located on? -
was an important one in understanding the issues discussed in this portion of the chapter. It also assisted in identifying which office site the respondent was from, as referenced several times earlier in the chapter.

The follow-up survey question to the floor occupied was:
Are any of the following items reasons that windows in your office don't get opened?
> *Potential for insects to enter through open windows*
> *Potential for birds or animals to enter through open windows*
> *Potential for a person to enter through open windows*

It was speculated that the first floor occupants would cite security issues and concern of a human entering through a window. Results of the questionnaire confirmed that (Chart 4.31). Office occupants near ground level are not the only ones with that concern, however. In the initial visits to offices in Portland, Oregon, an occupant on the third floor of a building stated a similar point. In that case, there was the roof of a lower portion of the building immediately outside office windows. That portion of the roof was accessible by stairs and doors from the upper floor. This suggests that design intentions must consider the type of window chosen, or other protective treatment to the window area, when there is potential for human entry at any level.

Figure 4.31   Floor Height as Determinate of What Enters Windows
(questions 9 & 10)

**Frequently or sometimes reasons that prevent
windows from getting opened**
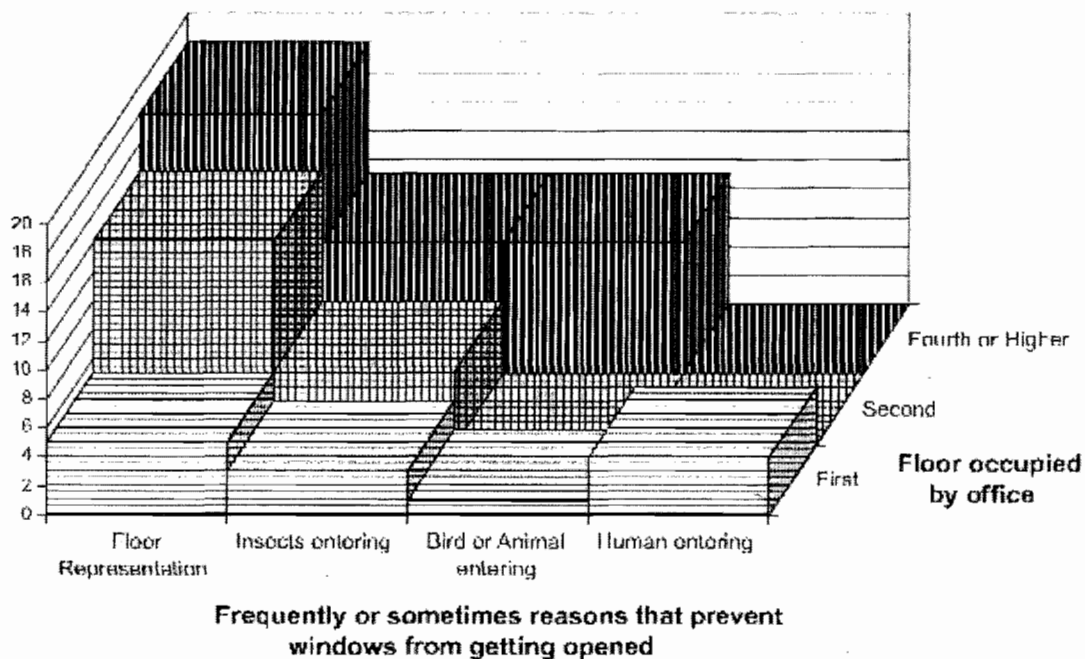
Figure 4.31 compares those things that can potentially enter through an open window. The first row of columns on the left ("Floor Representation") indicates the number of respondents from each floor level. This can then be compared proportionally to the number of responses in the other three rows of columns. When comparing the number of respondents representative of the various floor heights, a similar proportion of employees cited insects entering through open windows as possible reason windows do not get used.

In contrast to that, more respondents from the offices located on the fourth floor or higher were concerned about birds entering through open windows. This is in agreement with informal interviews conducted at that office, where windows left open one night by mistake allowed for pigeons to come into the office and trip the alarms. It was observed that there were no screens used on the windows of Office 3 (fourth floor), while there were screens on windows on Office 3's sixth floor windows, as well as Office 1 and 2 (first and second floors).

In Figure 4.32, floor height is paired with issues of noise and pollution. By representing the number of respondents from each floor (far right columns), one can make proportional comparisons. Most consistent with floor representation, respondents noted issues of pollution, pollen or dust at a similar percentage. In retrospect, it probably would have been more revealing to separate pollution from pollen, since two sites are quite urban and one is suburban, with a park just beyond the building.

Issues of noise break from the proportional representation of floor height, however. While previous studies report that distance from traffic noise usually is inversely proportional to noise experienced within an office, there is another factor to take into account here. The offices represented on the fourth & sixth floors are the most urban, in an area currently experiencing the noise and traffic associated with the construction of the new Minnesota Twins stadium just blocks away. This finding was also reinforced through informal interviews of occupants of that site, as noted earlier under the section on orientation.
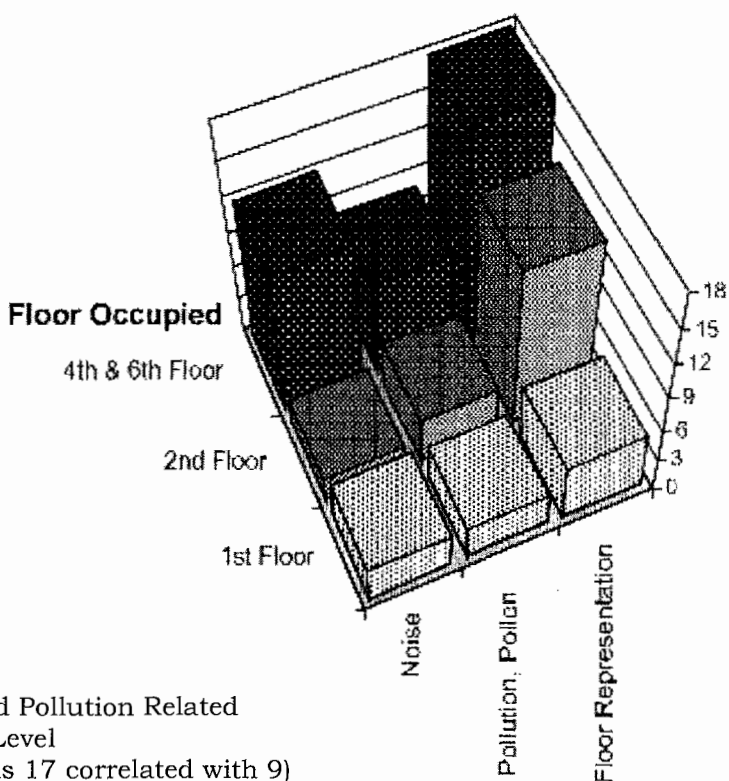
Figure 4.32   Noise and Pollution Related
                to Floor Level
                (questions 17 correlated with 9)

The office represented by the second floor is the most suburban, bounded on one side by a nature preserve, which might be an indication of the proportionally lower issues of noise cited by those office workers.

4.1.6 General Questions

To be successful, part of the qualitative process of observing human behavior and physical traces is to be open to what can be revealed. It is not about finding the ultimate Truth (Leedy, 2005), but instead "to find reflections of previous activity that was not produced in order to be measured by researchers" (Zeisel, 2006, pg 159). Documenting the natural setting of the three urban offices, conducting informal interviews, and finding evidence of people's interaction with windows has been, to some degree, illuminating. It also seems that the quantitative component of the research - the questionnaire - still allowed some insight into the qualitative aspects of life in the office environment.

This final portion of Chapter IV will discuss the findings from some of the more general questions posed in the survey, which elicited somewhat unforeseen information. It will also include a list of comments from the open-ended, two-part question at the end of the web-based questionnaire. Some of the information here gets at the heart of why operable windows are important to people working indoors, but also addresses a larger need to connect to the world around them.

The first question to lead the survey was not specifically about the Design Attributes of operable windows, but mostly an inquiry to how the occupants view windows in the office environment:

How important are the operable windows (those that can be opened and closed) in your office for the following: (from very important to very unimportant)
    Fresh air
    Cooling ability
    Other

The results were unexpected. Twice as many (55.6%) reported that fresh air was VERY IMPORTANT than said cooling ability was (27.8%). When totaling those who said VERY or SOMEWHAT IMPORTANT, fresh air still leads cooling, 91.7% to 66.7% (see Chart 4.33).
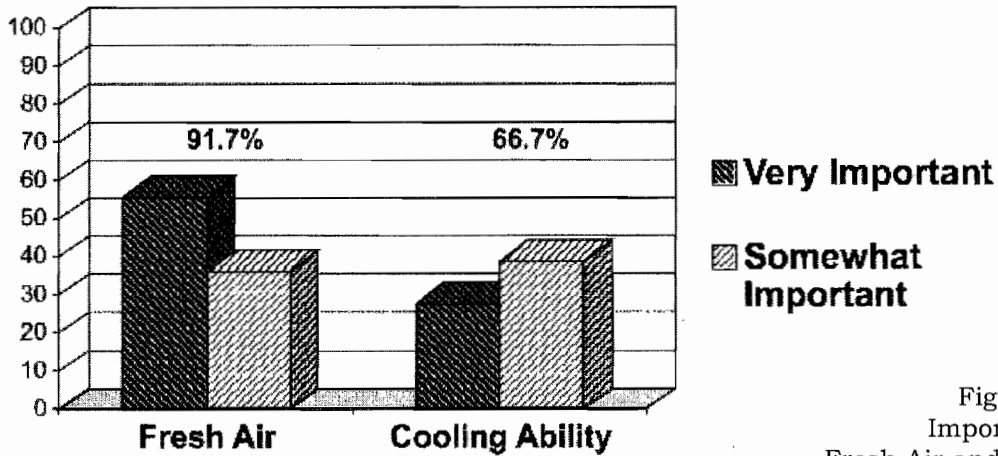
Figure 4.33
Importance of
Fresh Air and Cooling

Ninety-two percent of respondents stating that operable windows are important for fresh air is an important finding, significant in how architects and engineers move forward with fresh air delivery in buildings.

It also raises other questions, such as whether this high preference differs from place to place. This will be discussed further in the next chapter. Refer to Figures 4.34 and 4.35.

Figure 4.34
Importance of Fresh Air from Windows
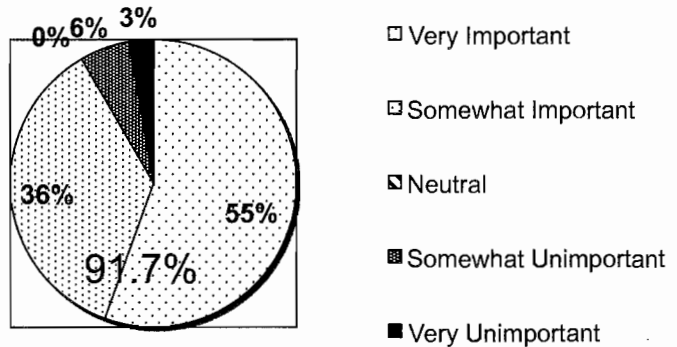
Figure 4.35 Importance of Cooling from Windows

"Having operable windows in the work environment is extremely important for me, mainly for fresh air but also for temperature control" (survey respondent)

- □ Very Important
- ▦ Somewhat Important
- ▨ Neutral
- ▣ Somewhat Unimportant
- ▦ Very Unimportant
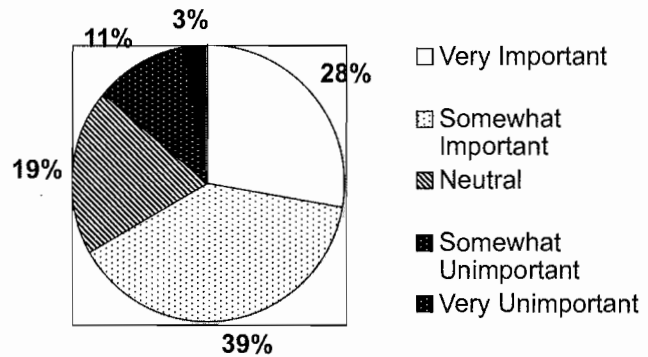
With the previous survey question, there was an option for respondents to elaborate on "Other" reasons operable windows are important. Two answers to the question of why windows were important were: *"workplace happiness"* and *"visceral connection to outside."*

The second and third questions of the survey were written primarily for comparative purposes when analyzing, verifying, or crosschecking other answers. Still, as stand-alone questions, they revealed some thought-provoking information, and spurred further questions, such as the leanings of respondents to the questionnaire: Were the 30% of the population who responded to the questionnaire more likely to open windows in the first place? Again, this will be discussed further in the final chapter.

SURVEY QUESTIONS
When the weather is conducive to using the windows, how often are the operable windows NEAREST YOU opened?

When the weather is conducive to using the windows, how often are the operable windows IN THE GENERAL OFFICE AREA open?

Figure 4.36   Frequency of Open Windows
(when weather is conducive to use of operable windows)
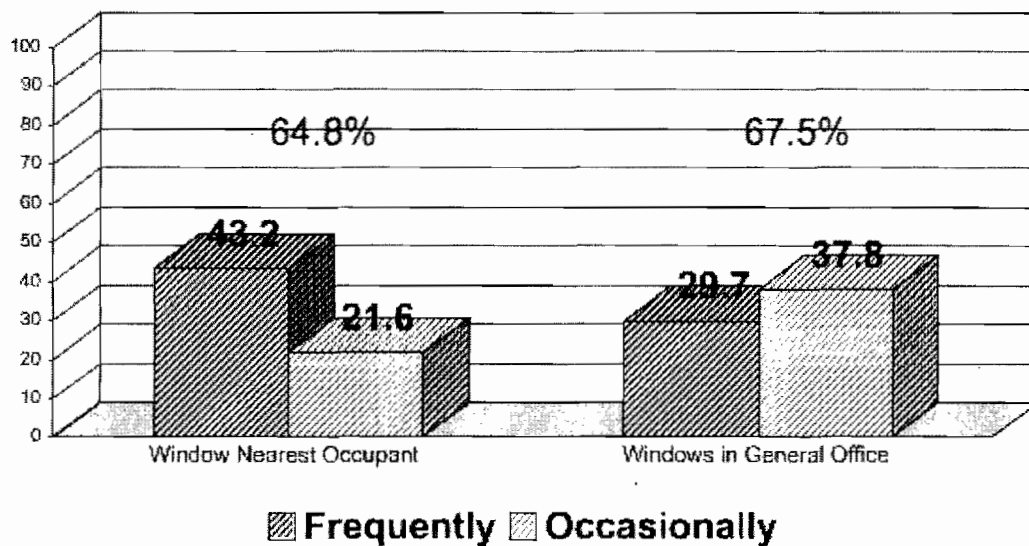
Figure 4.37   Open Windows near Occupant
(questions 1 & 2)
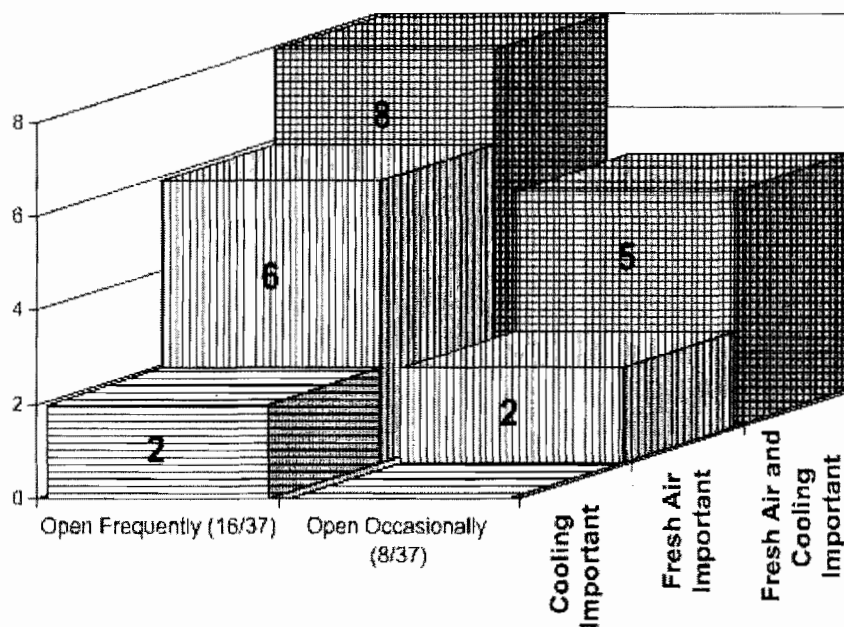
More information is revealed when pairing these general questions with others. Of those who have windows nearest them open FREQUENTLY, they have also listed fresh air and cooling (one or both) as VERY IMPORTANT (or at least SOMEWHAT IMPORTANT). What this says is that those who feel fresh air or cooling is VERY IMPORTANT have windows near them open frequently.

Personal control has been stated as an important factor in worker satisfaction and productivity (refer to Chapter II). The focus of this thesis is not about worker satisfaction, but about the occupant's ability to personally control operable windows related to the physical, designed attributes of those windows. Still, it was important to find out what the respondents' feelings were on personal control of their environment with the following question:

How important is it to be able to control the operable windows yourself?

Figure 4.38   Personal Control of Operable Windows
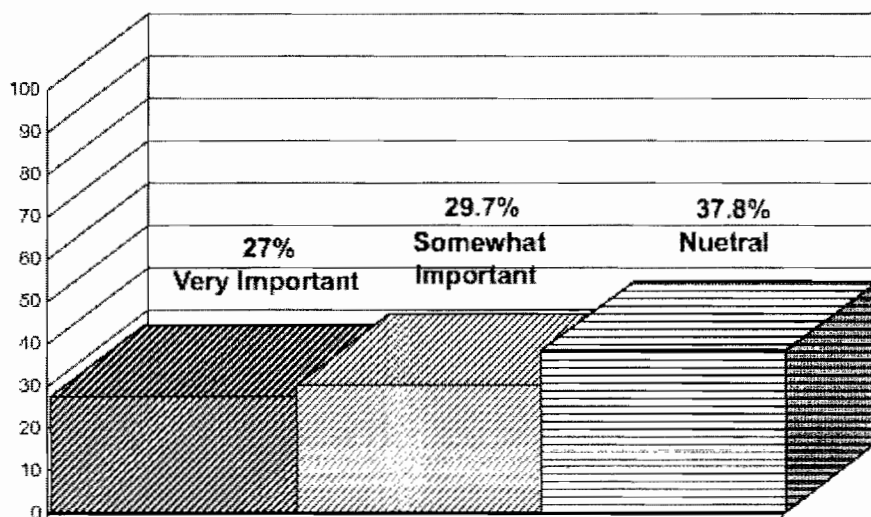
Of the ten respondents who said personal control was VERY IMPORTANT, all ten also reported that the windows nearest them were open FREQUENTLY, and eight of them said they open the windows themselves. This causes one to ask if the employees who value personal control of operable

windows are able to choose a spot near the window in their place of work, and might be a question for a future study.

Some of the most revealing information came by way of the optional open-ended questions at the end of the survey. They are all listed below, but some have been previously quoted in earlier sections of this chapter when appropriate to the Design Attribute they pertain to.

SURVEY QUESTIONS
The following questions require written answers and are optional:
 A. Are there any improvements you'd like to suggest for the design of operable windows for use in offices?
 B. Are there any other comments you'd like to make pertaining to your ability to use operable windows in your office?

SURVEY QUESTION
Are there any improvements you'd like to suggest for the design of operable windows for use in offices?

Suggestions of improvements for the design of operable windows included the following comments about window efficiency:

 "Upgrade to energy efficient"

 "Insulate them better. Windows in the winter are cold."

Other comments pertained to the weight of the windows, and the difficulty in opening them:

 "Our windows are very heavy (it's an older building) and opening them can be difficult, but I like having the option and we frequently open them."

 "Windows that only require one hand to open"

There were comments both in opposition and in favor of operable windows:

 "Automatic closing devices after a predetermined time the window has been opened. In our particular company, those who open windows for their own comfort do not take responsibility to assure they are closed at the end of the day."

 "More buildings should install them."

 "Put more in!"

It was surprising to find that not all employees knew they had operable windows in their offices – *"Make your employees aware that they are operable"* - as was also revealed in the first question under the category of "other" - *"I wasn't even aware that we had operable windows."* Overall the comments reveal that windows are an asset, but do have some issues with energy efficiency, heat loss, and the notion of personal responsibility for use of the windows.

SURVEY QUESTION
Are there any other comments you'd like to make pertaining to your ability to use operable windows in your office?

The second part of the final question asked for any additional comments, soliciting varied results. Four responses pertained to a lack of being able to use the windows, due to the facilities department requests that windows stay closed in preference of the mechanical system:

> *"Because our internal facilities and environment department request we keep window usage to a minimum and let the heat/cooling system function, we rarely open the small windows available to us."*

> *"Our Facilities Dept does not let us open windows, the building HVAC system regulates the temp. I would love it if we could open windows on appropriate days, but it is not my decision"*

> *"Let me know if I'm allowed to open them or not."*

> *"I believe the main reason we do not open windows is to ensure that temperature is set consistently to save on cost and be efficient. If the air is on and the windows are open it does not make sense, this is why we just leave them closed all the time."*

This is a widespread issue when operable windows are available, and a frequent reason used against installation of operable windows (or to permanently lock them, in the case of building restorations). This thesis is not able to address this issue, but at least can call attention to it. There has been a great deal of research that addresses multi-mode ventilation systems, allowing natural ventilation through operable windows and mechanical ventilation to co-exist.

However, there will still be those who will not be convinced of the benefit of natural ventilation:

> *"As mentioned in the previous answer, I do not believe in operable windows because of the lack of responsibility that the users have to make sure that they are closed at the end of their shift. In a temperature-controlled facility, there should not be operable windows in a DC environment or an office environment. Architects should look harder at the mechanical systems at the design stage of a build to assure total comfort throughout the building. Systems need to be zoned properly and an EMS or BAS system should be the controlling factor for the system."*

Some places accept that there will be some who want the windows open, even when air conditioning is being used. In Office 3 the office manager said that the southwest side of office opens windows, even when AC is on. She sends out emails, or turns the thermostat in that zone up to prevent AC from coming on in that section.

Personal control of one's environment enters into one of the responses:

> *The option to open a window is nice. I wish those sitting closer opened them more frequently. It is nice to have the option even if we don't use them that often as I think it make for a less caged in feel over all.*

With an acknowledgment that "personal control" needs to consider who will be affected:

> *The challenge is when your personal choice affects the comfort of others.*

An informal interview with one person in Office 3 revealed that there is no one person who controls the windows. In her case, she communicates with the person who sits next to her (a workspace away from window) to gauge comfort level, and determine if/how much window should be opened. She thought others in office were doing the same thing.

The general questions of the survey were more helpful and revealing than anticipated, and at the same time, probably more validating of some of the speculations made prior to conducting the research.

CHAPTER V

CONCLUSION

> *"Having operable windows in the work*
> *environment is extremely important for*
> *me, mainly for fresh air but also for*
> *temperature control."*
> (survey respondent)

In Chapter IV, outcomes and findings of the research conducted was discussed under the framework of the five design attributes of operable windows and how that affects occupants' level of personal control of those windows. This chapter offers further discussion and conclusions under the framework of the design attributes, addressing the relationship between findings and personal control.

Additionally, the research results will look at how the information might be used in the future as interpreted by those who make design decisions: architects and engineers (mainly mechanical), and the facility managers who have input and deal with the end product of the designs. Research findings elicit more questions, which can be addressed in future research.

5.1 Summary of Findings Related to Design Attributes

The most basic hypothesis of this thesis is: Less effort (physical, psychological) = Greater likelihood of window use. In general, this seems to hold true as results indicate, but there were several pieces in the research where this proved to be inconclusive, due to lack of evidence, the framing of questions, or other limitations that were unanticipated. Following are a summary of findings along with some conclusions drawn from each.

5.1.1 Operational Methods

Using three sites, with varying window types and hardware, revealed a difference in real and perceived operability of windows. When it came to the vertical position of the window in the wall, coupled with the size and weight of those windows, it was speculated that Office 3 would have the highest number of responses citing difficulty of use. Three out of four who stated windows were too low were from Office 3.

Actual testing during the site visit also revealed that a portion of the restored double hung windows were prone to heaviness and stiffness in the movement. There were also comments by occupants during the site visit, stating the need for assistance or a second person to lift open the windows. Of the three respondents who expressed that windows were too low for use, they also stated that the windows were either difficult or somewhat difficult to move, and that this sometimes determined if the windows were opened.

Physical trace observation revealed that some of the windows in Office 3 needed to be propped open, which could suggest excessive weight of windows, looseness in the track, or a combination of the two. At the same time, there were an equal number of occupants in Office 3 who had no problem with windows, or stated that operability depended on the window.

The windows easiest to open were those awning windows of Office 2 with a crank handle. These were also the newest windows of the three sites, installed in 2005 or 2006. Office 1 had windows that were primarily easy to open, considering both hardware and movement of window. These were a smaller awning window than in Office 2, and had a lever instead of a crank.

The conclusion, through a relatively small sampling, is that window operation (ease of movement or type of handle) *sometimes* determines if the windows get used. Age and condition of window and tracks most likely play a factor in the ability and effort needed to open windows. Inquiry of handle and levers revealed slightly more ease of use with cranks and levers than with a simple metal handle, but it is difficult to determine if these responses are complicated with movement, weight, or type of window operation.

5.1.1.1 Operational Methods – Research Limitations and Validity

Part of what contributes to the operation of a window is the physical ability and strength of the user. It is to be assumed that most windows today are designed to be easily operable. However, older windows are not always in the best of condition, even if repaired or rebuilt. The commitment of the occupant to want to open the window then comes into play when a window is difficult to manage. Will the benefits of the fresh or cool air outweigh the effort to open the window? A larger sampling of window types varying in age and conditions would potentially produce a more in-depth measure of how much the operational method influences occupant use. This might be an even stronger study if the user sampling was controlled too – as a representative sample of physical abilities, ages, or agility.

5.1.2 Proximity

Proximity seemed to be one of the greatest determinants of window use, according to this research, illustrated in Figure 4.10. Proximity was correlated with frequency of window use, and with positive responses that distance was a determinant of window use. Proximity, especially for those within 10 feet of the window, revealed a higher level of personal control, and a higher value placed by those occupants on personal control (Figure 4.11).

Relationship of desk to window also revealed the importance of proximity. Those directly next to the windows opened them more frequently themselves. For those who stated that there was another employee next to the window, then another employee opened those windows more frequently. While this seems an obvious conclusion, it supports the notion that proximity of the occupant to the window will determine window use. This is certainly something that should be considered in how workspaces are designed within the larger context and configuration of the floor plan.

5.1.2.1 Proximity – Research Limitations and Validity

Proximity of workspace to windows can be by occupant's choice or chance, or specified by the management. None of these issues were addressed

in this research. Proximity to windows may have determined those who chose to respond to the questionnaire, however, and raises some questions: Were those who answered the questionnaire more committed to using operable windows in the first place? Were they the employees seated closest to the windows, and whether by choice or chance, most aware of the operable windows in their vicinity?

Of those who participated in the web-based survey, 40.5% sat within 10 feet from a window, 29.7% within 20 feet, and 19.7% at 21 feet or more. These are factors that could determine and slant survey outcomes, and must be mentioned. From site visit information gathered, it was evident that there were fewer people sitting in close proximity to the windows, particularly in Office 2, which had cubicles as far as 60 feet or more from the window walls. Because the questionnaire participation was completely voluntary, it set itself up for being answered by those who deemed the subject important.

LEED addresses the issue of proximity in the Guidelines for *New Construction and Renovation (version 3)* under the section of "Indoor Environmental Quality Credit 6.2: Controllability of Systems: Thermal Comfort." The intent of this credit is to "Provide a high level of thermal comfort system control by individual occupants or groups in multi-occupant spaces and promote their productivity, comfort and well-being" (USGBC.org). Criteria to gain this credit includes the following stipulation: "Operable windows may be used in lieu of comfort controls for occupants located 20 feet inside and 10 feet to either side of the operable part of the window" (USGBC.org).

Proximity to operable windows is a piece of this study that has already been the subject of a considerable amount of research, but the results of this survey may validate occupant awareness of operable windows and their benefits when the occupants are in close proximity to them. It may be that those seated at a distance of 20 feet or more feel no benefits, therefore, have no real connection to operable windows. More accurate data might possibly be obtained if the sampling of occupants is evenly distributed according to window proximity.

5.1.3 Accessibility

Clutter, whether on sills, on the floor in front of the windows, or by blinds or shades, was not a significant deterrent to accessibility and window use, according to the research findings. Office 1 had only one of five respondents who indicated OCCASIONAL problems with the issues mentioned above. Respondents from Office 2 cited no obstructions whatsoever. Office 3 had a relatively small sampling, with four out of fourteen respondents stating furniture or objects on the floor OCCASIONALLY deterred window use, three citing window sill clutter, and two mentioning blinds or shades as an OCCASIONAL factor inhibiting window use.

Blinds or shades were cited as obstructions only in the cases where heat from solar gain or glare were also issues. This suggests that orientation has a relationship with window obstructions when use of low-hanging shades obstructs accessibility or sufficient airflow.

The flip side of obstructions prohibiting window access can be observed through physical traces, which could indicate that accumulation in front of windows is *evidence* that the windows are not used. Site visits looked at the situation from this perspective also.

Minimal clutter was noted during the site visit of Office 1. No obstructions were found in the site visit to Office 2, and none were indicated in the questionnaire responses. Office 2 was also the only office where all windows were accessed via a walkway, so there was no personal domain claimed at any of the windows. Office 3 has a shared walkway on one of the three office orientations, and while there were a few small items along the window wall, nothing seemed to be blocking the functioning windows.

5.1.3.1 Accessibility – Research Limitations and Validity

While obstructions proved to hold no major significance in the determination of personal control of operable windows, it appears that windows situated in a walkway will probably remain clearer of object accumulation. Other public or shared domains are more complex to understand. If there is an accumulation of objects in front of a window, one might need to understand

who placed them there, and what that person or persons' level is within the office environment. If administration or facilities placed objects in front of windows, other employees might feel more helpless to say or do anything about it. If coworkers were laying claim to the space, there might be negotiation to allow for items to be moved. Again, objects obstructing window use might be more an indication of disinterest in opening windows, so this potentially needs to be addressed more thoroughly in future research.

5.1.4 Orientation

As with Accessibility, Office 3 had the greatest representation, proportional to its questionnaire respondents, revealing that window use was related to orientation. Office 3 fronts a busy highway, so it was speculated that traffic noise would be an issue. During the site visit's informal interviews, occupants on the SW and SE workspaces described noise and dust from major construction as problematic.

In seventeen survey responses where noise affected occupants either FREQUENTLY or OCCASIONALLY, ten said it affected their decision to use the window. In the case of pollution affecting respondents either FREQUENTLY or OCCASIONALLY, seven of fifteen said it affected their decision to use the window. Dust, pollen and pollution were not major determinants of window non-use, but each site did have slight indication of that problem. Findings were fairly inconclusive for this area, and possibly might have been stronger if pollen was a separate category from pollution/dust.

Most significant as a determinant of window use related to orientation was glare, cited by Office 2 and 3. Heat from solar gain had the largest effect on Office 3, where two of its three orientations are southerly (southeast and southwest). Comments pertaining to the intense afternoon heat in the southwest corner were part of the reason for double blinds on that side of the office.

5.1.4.1 Orientation – Research Limitations and Validity

Informal interviews that took place during the earliest site visits indicated some confusion with occupants' perception of orientation, especially in Office 3, where the building was 45 degrees off of the cardinal directions. Having occupants identify their orientation might have solicited a clearer understanding of the relationship with orientation-related issues and occupants' use of windows. One possible solution would be to include a map of the floor plan in such a way where, if multiple orientations existed, questionnaire respondents could select a general orientation of where they were seated. This would have to be done in a manner that still allowed for anonymity.

5.1.5 Building Floor Height

If not a designed intention, building floor level should be, at the very least, a necessary consideration of operable window use. Speculation of occupant perception of windows related to floor height was verified in the research. In the case of Office 1, the questionnaire responses revealed that only those occupying the first floor were concerned about human entry through a window. The answer to an open-ended question exhibited the same:

> *"Worry of forgetting to close windows, and fear of robbery/theft sometimes prevents use of windows"* (survey respondent from Office 1 – first floor)

There was no conclusive evidence, nor proportional difference among the floor heights when addressing insects entering through windows. Both Office 1 and 2 had screens on their windows, which would control that problem. Office 3 did not have screens, though there was no significant indication that insects were a problem, other than one comment during the site visit of wasps entering. Even with that, there was speculation that wasps were coming in through small cracks in the wall of the 1886 building, instead of through the windows.

Office 3 had a slightly larger percent, proportionally speaking, of concern for birds entering through open windows, as was also predicted due to a previous event in that office. Without screens on the fourth floor windows of Office 3, the potential for birds was certainly greater, as they found out when windows were left open once overnight.

In previous studies (refer to resources cited in Chapter II), noise and building floor height have been shown to have an inverse relationship. With that in mind, one would speculate that those on the lower floors would indicate a higher annoyance with noise. That was not the finding in this thesis research, most likely due to office site locations. The offices with windows on the first or second floors were more suburban than the downtown office with the windows on the upper-most floors.

Pollution and pollen were again reported to be mostly proportional to the number of respondents from each office floor, therefore, inconclusive as a determinant of window use.

One unexpected item brought up in an informal interview was related to the human perception of safety. Due to the low 18" height of the sills on the large, double-hung windows in Office 3, one employee mentioned that some coworkers felt uncomfortable walking near the open windows fronting the shared walkway. Whether a real or perceived threat, it would certainly dictate the degree to which occupants are willing to open those windows, especially the further from the ground one would be. While this most likely would be a code issue in new buildings, historic buildings aren't always held to the same restrictions.

5.1.5.1 Building Floor Height – Research Limitations and Validity

Building floor height can be a fairly accurate determinant of identifying those things that might have direct access inside a window, or how people from the inside perceive their position in relationship to the distance from the ground. Floor height is not an accurate determinant of annoyance of noise, pollution, dust or pollen if the sites themselves are not a controlled variable within the research framework. Much research has already been done in the

area of noise and airborne particulates related to floor height (Chapter II), so finding support for that data was not a significant focus of this research.

5.2 Summary of General and Unexpected Findings

In previous research reviewed, a majority of the focus on operable windows and natural ventilation pertains to cooling and thermal comfort (See Chapter II). The questionnaire results, however, placed the importance of FRESH AIR significantly ahead of COOLING ABILITY when addressing question #1 of the survey:

How important are the operable windows (those that can be opened and closed) in your office for the following:
Fresh Air
Cooling Ability
Other

The results were unexpected, as it was assumed that the fresh air and cooling would be relatively equal in importance. Twice as many (55.6%) reported that fresh air was VERY IMPORTANT than said cooling ability was (27.8%). When totaling those who said VERY or SOMEWHAT IMPORTANT, fresh air still lead cooling, 91.7% to 66.7% (see Chart 4.33).

While this information is significant in the value that operable windows can provide, it may also be a reflection of cultural or climate bias. One assumption might be that in an extreme climate such as Minnesota, where windows must be closed for approximately half of the year due to cold temperatures, fresh air is scarce, and more valued. The stuffiness (real or perceived) of the sealed building has occupants yearning for fresh air in those precious few months when operable windows allow for it. This hypothesis is based, not on any data collected from the research, but from the researcher's personal experience living in the northern climate for several decades.

While ventilation systems have become much more advanced in allowing for fresh air exchange at a rate commensurate with human comfort and well-being, they still don't offer one thing that an open window can – that *smell* of fresh air! Reiterating literature reviewed in Chapter II, studies have found that

when staff were asked to compare naturally and mechanically ventilated offices, they reported that they "feel more invigorated" and "enjoy the sense of breathing in fresh air" much more in naturally ventilated offices than in sealed spaces (Saunders 2002).

Another surprise was the questionnaire comments suggesting that occupants were not always aware they had operable windows in their office. This would suggest that employees need to have an orientation on basic building use, especially if the office culture is one of environmental responsibility, and has purposely made the commitment to install or use operable windows as a means of lowering cooling loads, or improving employees' sense of personal control and quality of work environment.

While the majority of survey respondents seemed to value operable windows and their benefits, it is still apparent by their comments to the open-ended questions that mechanical ventilation is still seen, at least by some employees or facilities operations, as the primary or superior means of cooling and ventilating. Given that all three offices have indicated a commitment to environmental issues in their business ethos, the question begs, what needs to change to incorporate the use of operable windows more frequently and efficiently?

5.3 Design Implications Related to Attributes

When designing to incorporate operable windows to achieve the maximum benefits, there are a number of things to consider. The items listed below are primarily addressed to architects, interior designers, and facility managers, and are related directly to the results of this thesis and the design attributes:

Operational Methods:
- Making sure double hung windows are of a size and weight that are manageable for one person to open.
- Keeping all windows in good condition and working order, and frequently maintained.

- Designing windows at a vertical height from the floor that allows for users to easily reach the opening mechanism, handle, lever, etc., or be able to open the window without strain.
- Utilizing windows that stay open, when in that position, without excessive props, or concern for them falling or blowing shut when they are in use.
- Making sure windows have screens in places where insects or birds might be an issue.
- Educating staff and management on the optimal use for that particular type of window to gain best results and benefits.

Proximity:
- Designing buildings with a narrow floor plate allows not only for better cross ventilation, but also for closer proximity of all employees to open windows. (It also allows for natural light to come deeper within the spaces).
- Designing and arranging workspaces that are 20 feet or less from windows will enable more employees to use and benefit from the operable windows.
- Allowing employees who are more likely to use the windows effectively to sit near the windows.

Accessibility:
- Allowing for clear, easy access to operable windows, through the design of a shared walkway.
- Allowing for clear, easy access to windows by not allowing for furniture or other large objects to get between users and windows. This also has implications for storage design.
- Considering orientation of operable windows and how glare and heat from solar gain will be mitigated, so blinds or shades will not block use or benefits of operable windows.
- Incorporating windows that can be used universally, by people with varying abilities.

Orientation:
- Considering the site and neighborhood, and what factors might hinder the use of operable windows, such as excessive noise, pollen, or sources of dust or other pollution.
- Incorporating exterior shading devices, light shelves, etc. when windows are oriented towards the south, east or west.
- Using tinted or insulated glazing on windows as a means of reducing glare or heat from solar gain.

Building Floor Height:
- Becoming familiar with the neighborhood, understanding the degree of security issues that might need to be addressed to prevent humans or animals from entering through windows at ground level or higher.

- Noting what other buildings or objects are directly connected to the outside of the building, which may allow for human or animal entry at windows, even if office space is located on an upper floor. (Figure 5.1)
- Understanding the degree or intensity of annoyance that noise, dust, or other potential intrusive elements related to the floor level of that office.

Figure 5.1 Window accessibility from an upper roof garden or deck can still offer potential access to upper level windows, producing similar concerns as that of having windows open to the ground floor. The windows on the far left of the photo are part of an office space.

5.4 Other Methods of Incorporating Operable Windows

While this thesis does not seek to list all the potential methods for incorporating operable windows into the office environment, the literature review did reveal some alternatives, such as night ventilation, slab cooling, earth to air heat exchange, double-skin facades, courtyards and atriums, red-light/green light strategies combined with mixed mode and hybrid systems (Herkel, et al. 2008; Wagner, et al. 2007; Solomon 2006; Brager et al. 2005; Dissenhouse 2004; Gratia & DeHerde 2004; Pasquay 2004; Ivanovich 2002).

User adjustments and behavioral adaptations were also discussed in the literature, and are necessary – not alternative – considerations when natural

ventilation is implemented (Brown, et al. 2004; Goto, Matamura, Yoshino, Tamura 2007; Pfafferott, et al. 2004; Nicol and Humphreys 2002; Raja, et al 2001; Newsham 1997).

5.4.1 LEED, ASHRAE, and CIBSE

Other professional sources offer some suggestions for the incorporation of operable windows in buildings. LEED's *Green Building Rating System for New Construction & Major Renovations (version 3)* has several credits pertaining to operable windows and natural ventilation that can be referenced under the section of Indoor Environmental Quality (IEQ):

IEQ Prerequisite 1: Minimum Indoor Air Quality Performance
IEQ 1: Outdoor Air Delivery Monitoring
IEQ 2: Increased Ventilation
IEQ 6.2: Controllability of Systems: Thermal Comfort
IEQ 7.1: Thermal Comfort: Design
IEQ 7.2: Thermal Comfort: Verification

Referenced in the LEED Guidelines pertaining to the design for operable windows are the following:

ASHRAE 62.1-2004 Indoor Air Quality, and ASHRAE Standard 55-2004 Thermal Comfort Conditions for Human Occupancy

CIBSE (Chartered Institution of Building Services Engineers) Applications Manual 10: 2005, Natural Ventilation in Non-Domestic Buildings, specifically the flow diagram process for determining "that the natural ventilation is an effective strategy for the project" (USGBC.org).

5.5 Future Research

Future research related to this thesis could focus on fine-tuning or clarifying the questions and results, or controlling different variables to isolate the outcomes. Some of these ideas are suggested within this chapter, relating to specific design attributes.

An unexpected finding worthy of further investigation might be to make cultural or climatic comparisons on the importance placed on fresh air. Does fresh air hold more value than cooling in climates where people are forced to be indoors due to extreme cold temperatures? Are climates that allow more

outdoor living going to reveal that fresh air is not as important as cooling ability when using operable windows in their work environment? These are questions that would be interesting to probe more deeply.

5.6 Conclusion

Viewing the level of personal control of office occupants through the lens of the design attributes of operable windows is complex. It is important to recognize the multi-sensory issues that can have an effect on the use (real or perceived) of operable windows: personal preferences and beliefs, variations of perception due to culture, place, age, gender, or many other issues. Further research may include making more specific comparisons of operable window use, with the variable of climate or culture, or something as specific to age or gender.

Thinking holistically can assist the architect or designer in allowing for a greater degree of considerations to be addressed when designing for operable windows. Educating those in charge of the facilities, as well as users of buildings with operable windows is critical, especially when optimum efficiency in energy consumption and operations is desired. "It's not as simple as 'opening a window and it works" (Madsen, 2005). The education of users is one of the most important solutions to ensuring operable windows will be used more effectively for natural ventilation and cooling in the office environment.

We need to think of the future, not only for where we want to go, but from what we will have learned from our past – "Future Hindsight" (Brand, 1994). What will the role of operable windows be in the future? Our knee-jerk reactions to the less desirable qualities of operable windows gave us a half century of new construction that sealed buildings off from the outside, and we are now realizing the problems associated with that.

Pairing research on human behavior with operable window use can increase our understanding of how to design move effectively and efficiency. This, in turn, can benefit environmental, energy and resource consumption, economic concerns, and of human well being.

APPENDIX A

SITE INFORMATION

Minneapolis Climate Information

www.rssweather.com
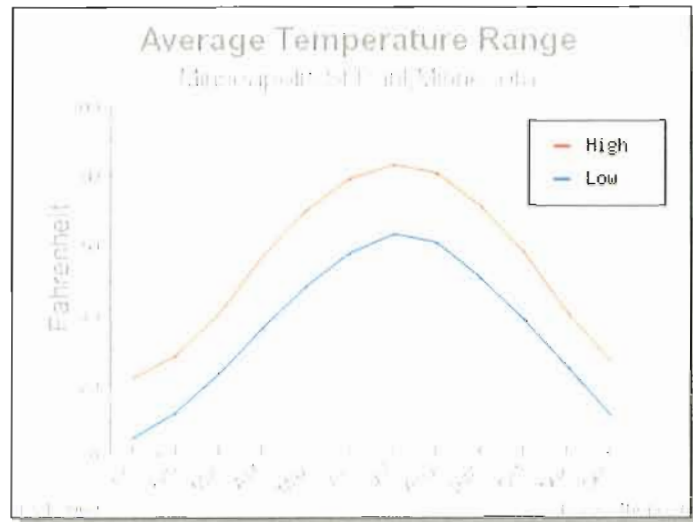
www.climate-zone.com

Minneapolis - St.Paul Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avg. Temperature	11.8	17.9	31.0	46.4	58.5	68.2	73.6	70.5	60.5	48.8	33.2	17.9	44.9
Avg. Max Temperature	20.7	26.6	39.2	56.5	69.4	78.8	84.0	80.7	70.7	58.8	41.0	25.5	54.3
Avg. Min Temperature	2.8	9.2	22.7	36.2	47.6	57.6	63.1	60.3	50.3	38.8	25.2	10.2	35.3
Days with Max Temp of 90 F or Higher	0.0	0.0	0.0	< 0.5	1.0	3.0	6.0	3.0	1.0	0.0	0.0	0.0	13.0
Days with Min Temp Below Freezing	31.0	27.0	25.0	11.0	1.0	0.0	0.0	0.0	0.0	8.0	23.0	30.0	156

Minneapolis - St.Paul Heating and Cooling	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Heating Degree Days	1649	1319	1054	558	244	41.0	11.0	22.0	167	502	954	1460	7981
Cooling Degree Days	0.0	0.0	0.0	0.0	43.0	137	278	192	32.0	0.0	0.0	0.0	682

Minneapolis - St.Paul Precipitation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Precipitation (inches)	0.9	0.9	1.9	2.4	3.4	4.0	3.5	3.6	2.7	2.2	1.6	1.1	28.3
Days with Precipitation 0.01 inch or More	9.0	7.0	10.0	10.0	11.0	12.0	10.0	10.0	10.0	8.0	8.0	9.0	116
Monthly Snowfall (inches)	10.2	8.2	10.6	2.8	0.1	< 0.05	< 0.05	< 0.05	< 0.05	0.5	7.9	9.4	49.7

Other Minneapolis - St.Paul Weather Indicators	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Wind Speed	10.5	10.4	11.3	12.2	11.1	10.4	9.4	9.2	10.0	10.6	11.0	10.4	10.5
Clear Days	8.0	8.0	7.0	7.0	7.0	7.0	10.0	10.0	10.0	10.0	5.0	6.0	95.0
Partly Cloudy Days	7.0	7.0	7.0	8.0	9.0	10.0	12.0	11.0	8.0	7.0	6.0	6.0	101
Cloudy Days	15.0	14.0	17.0	15.0	15.0	12.0	9.0	10.0	12.0	14.0	18.0	18.0	169
Percent of Possible Sunshine	53.0	59.0	57.0	58.0	61.0	66.0	72.0	69.0	62.0	55.0	39.0	42.0	58.0
Avg. Relative Humidity	57.0	72.0	71.5	68.0	64.0	66.0	68.5	70.0	72.0	71.0	69.5	73.0	75.0

BUILDING NAME	CLIENT(S) OCCUPYING OFFICE SPACE(S)	ARCHITECT	LOCATION		BUILDING TYPE/ USE	LEED CERTIFICATIO N OR OTHER STANDARDS
			BROAD	SPECIFIC		
The Phillips Eco Enterprise Center	The Green Institute (approx. 12 employees in open office spaces)	LHB Engineers & Architects	Minneapolis, Minnesota Metro area	Downtown Minneapolis: 2801 21st Ave. S. Ste 110 Minneapolis 55407	commercial office space	built in 1998 LEED NC Pilot Project
The Traffic Zone Visual Center for the Arts **Nat. Register for Hist. Places**	LHB, Inc. Engineers & Architects (approx. 45 employees)	LHB Engineers & Architects	Minneapolis, Minnesota Metro area	250 3rd Ave. North, Ste 450 Minneapolis 55401	commercial office space- architecture/ engineering firm	renovated in 1995 prior to LEED (built in 1886 as a farm implement warehouse and later appliance warehouse)
Quality Bicycle Products	Quality Bicycle Products headquarters (approx. 70 employees in open office spaces.)	LHB Engineers & Architects	Minneapolis, Minnesota Metro area	6400 W. 105th St. Bloomington (Mpls) 55438	commercial - product distribution center with administrative office space.	built in 2006 LEED NC Gold Certified

BUILDING NAME	SURROUNDING CONTEXT	SURROUNDING CONTEXT				BUILDING FLOOR OCCUPIED
		NORTH	SOUTH	EAST	WEST	
The Phillips Eco Enterprise Center	Warehouse / commercial / industrial corridor just southeast of downtown Minneapolis	1-2 story warehouse, commercial / industrial	Warehouse / commercial / industrial SW – Pioneers & Soldiers Memorial Cemetery	Warehouse / commercial / industrial Hiawatha lightrail line immediately to east, Hiawatha Ave. – busy, 10 – 12 lane highway,	Warehouse / commercial / industrial	First (ground) floor of 2-story building
The Traffic Zone Visual Center for the Arts	Downtown Mpls Warehouse dist., medium to heavy traffic nearby, building oriented 45 degrees off cardinal directions	Commercial, warehouse	3rd Ave. N. (I_394), large parking ramp, further southwest – Target Center and MN Twins stadium construction	3rd Ave. N. (I-394), Washington Ave. N., commercial / warehouse	Parking lots, parking ramp (southwest), 3rd street north (elevated highway)	Fourth & sixth floor of 6-story building
Quality Bicycle Products	Suburban location in Bloomington, a suburb just south of Minneapolis	Hyland Lake Park Preserve	Commercial / industrial, Old Shakopee Rd (4 land hwy) approx. 1 ½ blocks south	Railroad immediate east, residential past that	Commercial / industrial across parking lot, leg of park behind that	Second floor of 2-story building

BUILDING NAME	ORIENTATION OF WINDOWS				GENERAL PLAN OF OFFICE	GENERAL OFFICE CULTURE	PERSON(S) HAVING CONTROL OF WINDOWS
	REGARDING GENERAL ORIENTATION	RE: SOLAR GAIN	RE: NOISE SOURCES	RE: POLLUTION SOURCES			
The Phillips Eco Enterprise Center	All are facing NNW.	Nothing reported	Nothing reported	Nothing reported	Open plan, med. high cubicles, linear layout along windows, two desks deep at most	Non-profit, business casual, work focuses on environmental and community issues	Whoever is closest to the window, or in the cubicle section with the window
The Traffic Zone Visual Center for the Arts	SE, SW, NW	SE, SW	Twins stadium construction to SW	Some dust from construction vehicles on street below	Open plan, low cubicles, two sides have desks next to windows, one side desks separated by open circulation	Architecture /Engineering firm, business casual yet professional, environmentally focused, esp. architecture	Those who sit closest to operable windows are encouraged to communicate operating intentions
Quality Bicycle Products	NW and SE	South side reports, use shades	Nothing reported	Nothing reported	Open plan, high cubicle maze, area next to windows open for circulation.	Very casual, bring dogs to work, many social and environmental initiatives.	Those closest, but Facilities sends out messages pertaining to window use.

BUILDING NAME	WINDOW OPERATIONAL METHOD	WINDOW OPERATING HARDWARE	EASE OF WINDOW OPERATION	WINDOW HEIGHT FROM FLOOR (hardware)
The Phillips Eco Enterprise Center	Awning on bottom third of all windows	Latch/lever that turns to the side and window pushes out	Moves easily	36" off of floor
The Traffic Zone Visual Center for the Arts	Large, original 1896 double hung windows	Attached or grooved handles on window frame	Some sticky, some heavy and need two people to open, some glide smoothly	4th floor windows: 18" from floor 6th floor windows: 25" from floor
Quality Bicycle Products	Awning windows in conjunction with fixed and spandrel to form glass wall	Crank	Moves easily	53" off of floor

2nd Floor Plan (Office 2)
Quality Bicycle Products Administrative Offices
Minneapolis, MN

ot to scale

NORTH

4th Floor Plan (Office 3)
LHB Engineers and Architects, Inc.
Minneapolis, MN

Not to scale

NORTH

NORTH

JASON 6926 | CASSIE 6930 | JEFF | NEIL 6968 | RYAN R. 6947 | DAWN 6938 | MARY 6937

CJ 6917 | LYDIA 6956 | JIM 6921 | NICK 6942 | GARY 6943 | TIM W. 6935 | TERZA 6934

RYAN F. | OPEN

MICHAEL S. 6966

TIM K 6945

BILL B/

MIKE 6920

BRUCE CORNWALL 6915

MTG. AREA

BRAINSTORMING

LAURA 6928 | KC 6919

TINA | SARA

DEREK 6918 | MARK K.

OPEN

STEVE H 6932

MAUREEN 6954 | ANDY 6925

TJ AHN 6931 | KIM 6955

ANNE 6938 | BILL 6962 | OPEN | OPEN | ROGER 6957

BEN 6939 | JESS 6960 | NICK V. 6963 | TROY | STEVE 6940

BECKY D

RECEPTION

LIBRARY

PLOTTERS

1 LHB OFFICE LAYOUT - 4TH FLOOR
NTS

MINNEAPOLIS OFFICE LAYOUT: UPDATED 09.16.08

6th Floor Plan (Office 3)
LHB Engineers and Architects, Inc.
Minneapolis, MN

Not to scale

NORTH

FUTURE PLOTTER

SM. CONF. RM.

NICK

DANIEL RANDI

DRAFTING TABLE

EVAN

RICK
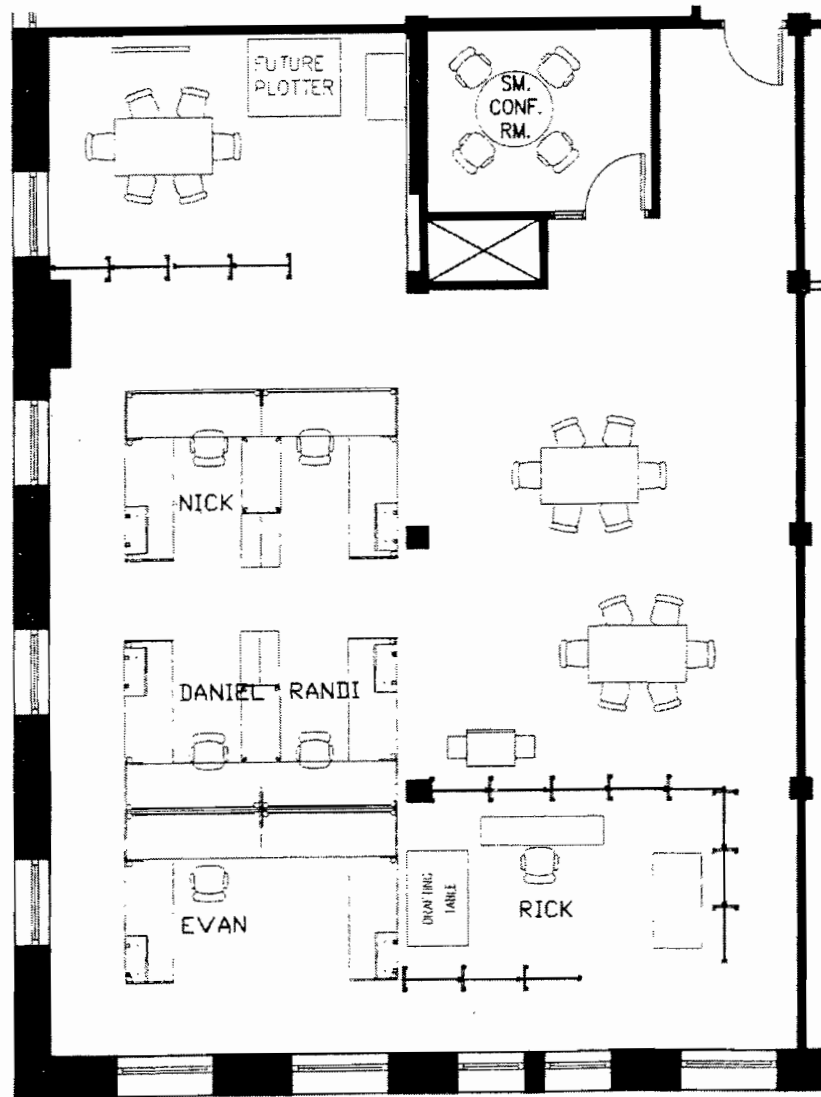
2 LHB OFFICE LAYOUT — 6TH FLOOR
NTS

APPENDIX B

SURVEY, CORRESPONDENCE

OCCUPANT SURVEY OF OPERABLE WINDOW DESIGN AND USE IN OFFICES

1. How important are the operable windows (those that can be opened and closed) in your office for the following:

	very important	somewhat important	neutral	somewhat unimportant	very unimportant	Rating Average	Response Count
Fresh Air	**55.6% (20)**	36.1% (13)	0.0% (0)	5.6% (2)	2.8% (1)	1.64	36
Cooling Ability	27.8% (10)	**38.9% (14)**	19.4% (7)	11.1% (4)	2.8% (1)	2.22	36
Other	25.0% (3)	8.3% (1)	**50.0% (6)**	8.3% (1)	8.3% (1)	2.67	12
					Other (please specify)		4
					answered question		37
					skipped question		0

2. When the weather is conducive to using the windows, how often are the operable windows NEAREST YOU opened?(Those windows nearest your personal workspace)

|	frequently	occasionally	don't notice	rarely	never	Rating Average	Response Count
(please choose most appropriate answer)	**43.2% (16)**	21.6% (8)	8.1% (3)	21.6% (8)	5.4% (2)	2.24	37
					answered question		37
					skipped question		0

3. When the weather is conducive to using the windows, how often are the operable windows IN THE GENERAL OFFICE AREA open? (windows other than those nearest you)

	frequently	occasionally	don't notice	rarely	never	Rating Average	Response Count
(please choose most appropriate answer)	29.7% (11)	**37.8% (14)**	10.8% (4)	18.9% (7)	2.7% (1)	2.27	37
					answered question		37
					skipped question		0

4. Which of these situations best describes the distance you sit from an operable window within your work place?

		Response Percent	Response Count
A. Work area 0-10 feet from an operable window		40.5%	15
B. Work area 11-20 feet from an operable window		29.7%	11
C. Work area 21-30 feet from an operable window		16.2%	6
D. Work area greater than 30 feet from an operable window		13.5%	5
		answered question	37
		skipped question	0

5. Does the distance that you sit from the window determine whether or not you open or close the window?

	yes	sometimes	no	N/A	Rating Average	Response Count
(please choose most appropriate answer)	54.1% (20)	24.3% (9)	18.9% (7)	2.7% (1)	1.64	37
					answered question	37
					skipped question	0

6. Which of these situations best describes the relationship of your workspace (cubicle, desk) to the operable window(s)?

		Response Percent	Response Count
A. There is nothing between the window and my work area (the window is directly accessible to me).		21.6%	8
B. There is a walkway, corridor, or shared general workspace between the window and my work area.		16.2%	6
C. There is another employee workspace between the window and my work area.		29.7%	11
D. There are several employee workspaces between the window and my work area.		32.4%	12
		answered question	37
		skipped question	0

7. Does the relationship of your workspace to the window determine whether or not you open or close the window?

	yes	sometimes	no	N/A	Rating Average	Response Count
(please choose most appropriate answer)	55.6% (20)	33.3% (12)	5.6% (2)	5.6% (2)	1.47	36
					answered question	36
					skipped question	1

8. If there is an operable window near you, who is most likely to open or close it?(select any that apply)

	Response Percent	Response Count
A. Yourself	32.4%	12
B. Coworker who sits closer to the window	56.8%	21
C. Coworker who prefers to use the windows more than you do	21.6%	8
D. Designated employee or management	5.4%	2
E. No one opens the operable window closest to you	16.2%	6
	answered question	37
	skipped question	0

9. What floor level is your personal office workspace located on?

	Response Percent	Response Count
A. Ground level	13.5%	5
B. Second floor	37.8%	14
C. Third floor	0.0%	0
D. Fourth floor or higher	48.6%	18
	answered question	37
	skipped question	0

10. Are any of the following items reasons that windows in your office don't get opened?

	yes	sometimes/possibly	no	Rating Average	Response Count
A. potential for insects to enter through open windows	13.5% (5)	29.7% (11)	56.8% (21)	2.43	37
B. potential for birds or animals to enter through open windows	8.1% (3)	21.6% (8)	70.3% (26)	2.62	37
C. potential for a person to enter through open windows	8.1% (3)	2.7% (1)	89.2% (33)	2.81	37
			answered question		37
			skipped question		0

11. Do the following effect the use of the operable window(s) in your vicinity?

	frequently	occasionally	not applicable	rarely	never	Rating Average	Response Count
A. blinds or shades get in the way of opening the window	0.0% (0)	8.1% (3)	13.5% (5)	16.2% (6)	62.2% (23)	4.32	37
B. books, plants, or other objects on window sills prevent use of the window	0.0% (0)	10.8% (4)	10.8% (4)	13.5% (5)	64.9% (24)	4.32	37
C. furniture or large objects on floor area in front of window prevent use of the window	0.0% (0)	13.5% (5)	8.1% (3)	16.2% (6)	62.2% (23)	4.27	37
					answered question		37
					skipped question		0

12. Are the operable windows in your office too high from the floor, too low to the floor, or about the right distance from the floor for letting people use them?

	too high	just right	too low	Rating Average	Response Count
(please choose most appropriate answer)	0.0% (0)	88.9% (32)	11.1% (4)	2.11	36
			answered question		36
			skipped question		1

13. Does the handle, lever, or crank on the window make the window easy to use, or difficult to use?

	easy to use	depends on the window	difficult to use	N/A	Rating Average	Response Count
(please choose most appropriate answer)	51.4% (19)	21.6% (8)	18.9% (7)	8.1% (3)	1.65	37
					answered question	37
					skipped question	0

14. Does the handle, lever, or crank on the window ever effect the decision to open a window?

	yes	sometimes/possibly	no	Rating Average	Response Count
(please choose most appropriate answer)	5.4% (2)	18.9% (7)	75.7% (28)	2.70	37
				answered question	37
				skipped question	0

15. How easily does the window nearest you open (how it glides in the track, or swings open)?

	easy to use	somewhat easy to use	don't notice/ not applicable	somewhat difficult to use	difficult to use	Rating Average	Response Count
(please choose most appropriate answer)	24.3% (9)	35.1% (13)	16.2% (6)	21.6% (8)	2.7% (1)	2.43	37
						answered question	37
						skipped question	0

16. Does the ease or difficulty in the window's movement (opening and closing) effect whether or not the window nearest you gets used?

	yes	sometimes/possibly	no	Rating Average	Response Count
(please choose most appropriate answer)	0.0% (0)	45.9% (17)	54.1% (20)	2.54	37
				answered question	37
				skipped question	0

17. Do any of the following conditions affect your sitting / working position at your desk?

	frequently	occasionally	don't notice	rarely	never	Rating Average	Response Count
A. heat from solar gain (direct sunlight heating window and inside of office space)	13.5% (5)	35.1% (13)	16.2% (6)	24.3% (9)	10.8% (4)	2.84	37
B. noise through an open window	5.4% (2)	40.5% (15)	13.5% (5)	27.0% (10)	13.5% (5)	3.03	37
C. pollution, dust or pollen through an open window	5.4% (2)	35.1% (13)	21.6% (8)	18.9% (7)	18.9% (7)	3.11	37
D. glare from light through a window	24.3% (9)	43.2% (16)	13.5% (5)	16.2% (6)	2.7% (1)	2.30	37
						answered question	37
						skipped question	0

18. Do any of the issues above effect your decision of whether or not the window nearest you gets used?(select all that apply)

		Response Percent	Response Count
A. Heat from solar gain		36.1%	13
B. Noise through the open window		27.8%	10
C. Pollution, dust or pollen through the open window		19.4%	7
D. Glare from window		19.4%	7
E. None apply		47.2%	17
		answered question	36
		skipped question	1

19. How important is it to be able to control the operable windows yourself?

	very important	somewhat important	neutral	somewhat unimportant	very unimportant	Rating Average	Response Count
(please choose most appropriate answer)	27.0% (10)	29.7% (11)	37.8% (14)	5.4% (2)	0.0% (0)	2.22	37
						answered question	37
						skipped question	0

20. The following questions require written answers and are optional:

	Response Percent	Response Count
A. Are there any improvements you'd like to suggest for the design of operable windows for use in offices?	66.7%	12
B. Are there any other comments you'd like to make pertaining to your ability to use operable windows in your office?	72.2%	13
answered question		18
skipped question		19

Email Correspondence with Site Contacts: Site Visits

The following email messages are examples of the correspondence conducted with contacts at each of the three sites pertaining to site visits and data collection. While not every email correspondence is listed below, examples of each stage of the process were selected.

9/11/08

Hi █,

I'm excited to hear that you are willing to participate in this research related to operable windows! I hope the information can assist you and your company also, in understanding how some of the green strategies incorporated in █ new building are actually working for you.

As I believe I mentioned on the phone, I am an architect working on a graduate research thesis, and awaiting approval from both my advisor and the university before actually visiting, and interviewing you and others. I'm guessing it will be another month, due to administrative paperwork, but will be in contact with you as soon as I have some dates in mind.

Thank you again for getting back to me, and I'll keep you posted on the progress of the process! I look forward to meeting you in person.

Enjoy the weekend!
Joan Vorderbruggen, AIA

9/30/08

Hello █,

I am contacting you regarding our past email conversation about me visiting █ █ office spaces. As mentioned previously, I am researching office spaces that have operable windows, and will be sending out a questionnaire to voluntary participants, inquiring of their use of operable windows. While that piece of the research is still in the approval stage, I would like to visit your office again for preliminary documentation of the office space and the operable windows. This visit would include my taking photographs of the office layout, windows, and work stations in relationship to proximity to the windows, with care taken to respect your employees while at work. I will be taking some measurements of distances between work stations and windows, as well as window height in the walls. I do not intend on having any major contact with the employees, unless someone seems to want to discuss their use of windows in that space. I would also like to meet with you briefly during the visit, however, would not expect for you to be available while I'm taking measurements, etc., unless you feel more comfortable doing that.

If this sounds acceptable to you, I would very much like to arrange for a visit next week. I would suspect that the visit and documentation would take a couple of hours at the most, and am open to any suggestions or restrictions that you feel need to be employed by me at the time of the visit.

The potential dates I am looking at are Tuesday October 7, Wednesday October 8, or Thursday October 9th. If any of these dates work, I would appreciate it if you could tell me which ones, and what time preferences you have. I will be coordinating with two other sites, so if you have a couple of time slots in mind that you could convey to me, that would be fantastic.

Again, I truly appreciate your willingness to assist me with this research, and look forward to meeting with you!

Sincerely,
Joan Vorderbruggen, AIA

10/15/08 ███

Hi ███,

I want to thank you for allowing me to collect information at ███ yesterday. I enjoyed meeting you and gaining a better understanding of how your office functions in relationship to the operable windows. I was wondering if you or facilities management happen to have a floor plan layout of the work stations in relationship to the windows on both north and south sides, which I could then better understand occupant's positions. A pdf would be fantastic, but if you have it in some other format, I should be able to access it from another computer if not my own.

I'll be in touch about the questionnaire.

Again, I greatly appreciate your assistance on this research!

Best regards,
Joan Vorderbruggen, AIA

Email Correspondence with Site Contacts: Questionnaire Distribution

The following email messages are examples of the correspondence conducted pertaining to the questionnaire and its distribution to employees. While not every email correspondence is listed below, examples of each stage of the process were selected.

12/1/08

Hi ███████,

I want to thank you again for your assistance with helping me in the research of operable windows, and your time spent with me so far. Allowing me to visit your office space to collect information has been a valuable piece to my research! If, at this point, you think this message should be forwarded to someone else beside yourself, please feel free to do so, or let me know who I should contact.

I am happy to report that the questionnaire for office occupants has been approved by the appropriate university committees, and is ready to distribute to your office. I greatly appreciate your willingness to participate in this piece of the research, and would like to honor your work environment as best as I can by making this component as simple, unobtrusive, and brief as possible. I am looking for your input on how to do this.

The questionnaire is voluntary and consists of 20 questions, primarily multiple and scaled choices pertaining to operable windows and their use. It should take no more than 20 minutes to complete. The plan is to have employees link to a website where they can then answer the questions with complete anonymity. If you approve of this method, I need to understand from you the best way for me to distribute the website link to the employee base. I am not asking for personal emails, but am wondering if there is some way that I could send out a mass email message to your employees, to allow them to simply click onto the link which opens the questionnaire website. It is important that this message comes from me and not through your administration; I don't want your employees to feel that this questionnaire is mandatory, or will in some way effect their work evaluations.

If there is no easy method for me to send an email out to your office employees to allow a link to the questionnaire website, then the other method would be for me to distribute the questionnaires to your office in hard copy form. Hard copy distribution could occur in a couple of manners. I could mail a packet to your office for distribution and completion, or I could personally visit on a day of your choice, distribute the questionnaires in the morning, and pick them up at the end of the day. Again, I am looking for your preference in knowing how your office will function most efficiently, and what will be the least invasive of time and schedules. I am also looking for your input on what method might produce the highest possible response to questionnaires.

I am seeking a way to work with you and your office, to make this process as quick and easy as possible, yet still provide an ample number of responses to assist with the research. I am hoping that you will find the outcomes helpful to you as well! Please let me know what method will suit you and your office the best, considering ease of access to the questionnaire, and the timing of its distribution. Obviously, the closer we get to the holiday season, the greater the chances are that people will be taking time off. I realize everyone is busy, and I am incredibly grateful to you and your employees to take the time to assist in this research!

Please feel free to contact me at your earliest convenience. I may follow up with a phone call in the next couple of days if I haven't yet heard from you.
Thank you and I look forward to hearing from you!

Best,
Joan Vorderbruggen

12/1/08

Joan,
Hello! Happy December.

I think the best way would be to use Survey Monkey, as we use this website for most of our "polling" of employees. If you set up the survey and provide the link to me I will distribute it to employees. ....of course I'd want a guideline of which types of employees you are looking for.

■

12/8/08

Hi again! As a thank you to you and your office for participating in this survey, I would like to send you a token of my appreciation. We have a local candy store here that specializes in covering locally produced foods (potato chips, for example) in chocolate. They seem to be a big hit with everyone! Can you please send me an approximate number of people in your office who will be receiving the questionnaire link? I'll send a treat your way!

Thanks!
Joan Vorderbruggen

12/8/08

Joan,
I sent the link to roughly 70 people.
This way I'd hope you'll get at least 30 to 40 responses.

Thanks for the treats...it's unnecessary, but we'll never say no to that! Chocolate potato chips? I'm intrigued!
■

12/16/08

Joan, We got your chocolates...how fun!! I realize it may be too late but I sent out the survey to staff again just in case we could get more takers... Thanks a million.

Follow-Up and Thank You

Several weeks after the survey link had been distributed, thank you cards accompanying boxes of chocolate from a local candy-maker were sent to each office. A reminder of the questionnaire was also listed on the card, in hopes that there would be a few more participants encouraged to take the survey.

Thank You

for answering
the Operable
Window
Questionnaire!

(distributed via email
on December 8th)

THANK YOU for answering the OPERABLE WINDOW QUESTIONNAIRE

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