THESIS

AN INVESTIGATION OF PERCEIVED BEHAVIORAL CONTROL (PBC), AND ENVIRONMENTALLY RESPONSIBLE BEHAVIOR (ERB): A CASE STUDY OF OCCUPANTS IN A HIGH PERFORMING BUILDING

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ABSTRACT

AN INVESTIGATION OF PERCEIVED BEHAVIORAL CONTROL (PBC), AND ENVIRONMENTALLY RESPONSIBLE BEHAVIOR (ERB): A CASE STUDY OF OCCUPANTS IN A HIGH PERFORMING BUILDING

Energy efficiency continues to be a challenge faced by the built environment. Research on determinants of energy efficiency identifies occupant behavior as the weakest link in attainment of energy efficiency goals set for high performance building designs. Environmentally Responsible Behavior (ERB) could be the answer to the improved daily functional energy efficiency of buildings. Previous studies suggest that if ERB and Perceived Behavioral Control (PBC) are positively correlated, indicating that the rate of ERB will be higher by building occupants in high performing buildings. This study focuses on the relation between ERB and PBC in regard to thermal conditions. The data used for this study comes from building occupants through an online survey, which includes both open-ended and close-ended questions that act as multi-item indicators to measure ERB, PBC, and building features. The lack of control experienced by the building occupants over the thermostat posed challenges to adequately studying the correlation between ERB and PBC in this case study. Analysis of the responses to the open–ended questions provides a better understanding of occupants' discomfort and their behavior intentions related to energy efficiency. The results of this study show that for high performance building to obtain the aggressive goals for energy efficiency, the building design not only needs to well-thought out and coordinated, but it must also meet building occupants' need for both comfort and productivity.

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CHAPTER I

SCOPE OF RESEARCH

Improving the energy efficiency of high performing buildings is of great value as buildings currently consume about 40% of the energy in the United States. Despite these steps taken towards energy consumption reduction, high performing buildings are still not as energy efficient as they are designed to be. This insufficient level of energy performance could be improved if building occupants exhibited Environmentally Responsible Behavior (ERB). In this study, ERB is when an individual or group makes choices to help protect the environment in general daily practice, and specifically participates in actions contributing to less energy consumption (Mobley, Vagias, & DeWard, 2009). Since energy is not used by buildings but rather by building occupants, occupants' behaviors can either hinder or facilitate reaching energy efficiency goals. To better understand ERB, this study examines the relationship between occupants' ERB and their perceived behavioral control (PBC). The focus of this study is to better understand how environmental factors can impact PBC and ERB.

Problem Statement

According to the Theory of Planned Behavior, PBC directly and interactively affects the behavior exhibited by an individual. Ajzen (1991) and Ajzen and Madden (1986) found that factors such as values, attitude, norms both personal and social, and PBC affect behavior in general. Additionally, it was found that factors such as attitude, personal and social norms, knowledge of the issue, organizational culture, individual sense of responsibility, locus of control, and PBC also determine whether nor not an individual exhibits ERB.

Occupant behavior is often cited as a key reason why high performance buildings struggle to achieve the energy efficiency goals. Building occupant behavior has potential to eliminate the gap between energy efficiency goals and actual building performance. Both ERB and PBC have previously been studied both separately and in other social behavior models. Despite these studies, building occupants' PBC over their thermal comfort and its relation to ERB has not been studied in depth.

Goals and objectives

The goal of this study is to investigate the correlation between occupants' ERB and their PBC related to their thermal comfort. The following objectives were identified for this study:

- Conduct a literature review to understand ERB and its various influential factors.
- To develop a survey instrument to gather data on the daily behavior of building occupants and assess whether or not they exercise ERB.
- Analyze data collected from the survey instrument.
- Develop conclusions and recommendations based on data analysis.

Research Questions

The research question guiding this study is:

RQ: Does the PBC in regard to thermal conditions experienced by building occupants improve the rate of ERB exhibited by building occupants?

Limitations

Behavior is a concept that can be affected by various factors such as values/beliefs, norms, attitudes, and perceived behavioral control, according to the Theory of Planned Behavior (Ajzen, 1991). This study focuses on the relationship between ERB and PBC regarding thermal conditions is studied with an objective of providing a conducive surroundings for building occupants to exhibit ERB. To collect data for this study, an e-survey was constructed and distributed to a convenience sample of building occupants on the Colorado State University (CSU) campus. Thus, the potential for bias in the results derived could exist.

Researchers Perspective

There are multiple motives behind a person's behavior. ERB could originate from multiple motives out of which a hedonic motive, also known as a gain motive, can arise. A gain motive is one that focuses on improvement of one's feelings. This motive surfaces in situations by which one could potentially avoid extra effort, negative events and thoughts, seeking both direct improvement in self-esteem and excitement. Since these factors are based on gain for oneself, it can easily become the highest motivator for an individual to exhibit a certain behavior (Lindenberg & Steg, 2007).

Looking into PBC, it was also seen that improved rate of control provided to building occupants would increase the perceived level of comfort. This assumption suggests that by adapting to one's environment through the availability of control provides an adaptive opportunity to increase one's rate of exhibiting 'forgiveness' to uncomfortable surroundings (De Dear, Brager, Reardon, & Nicol, 1998). This gave rise to questions such as, 'Does improved sense of perceived control over one's thermal comfort level in a work space by providing the opportunity for an individual to do so encourage an individual to exhibit ERB?' Based on the Theory of Planned Behavior, applying the various affecting factors and understanding the relationship between ERB and PBC could be a step towards advancing this area of research.

CHAPTER II

ENERGY EFFICIENCY AND OCCUPANT BEHAVIOR

The first objective towards accomplishing the research goal was to understand various Environmentally Responsible Behavior (ERB) determining factors that alter the rate at which ERB is exhibited by building occupants. Although there have been substantial steps taken in contribution towards the built environment in the form of improved technology and green building design features, building occupants have not been considered as a major determinant of energy efficiency. As a result, many high performing buildings, even with meeting design requirements, suffer in their functioning efficiency (Asheim et al., 2014).

While improved technology is being produced and installed with the goal of improving the energy efficiency of buildings, the persuasiveness of technology for buildings to exhibit ERB would be key (Fogg, 2009). Building energy efficiency can easily be considered, as a social issue where improving the behavior of building occupants is the untapped potential (Masoso & Grobler, 2010). Thus, having a better understanding of constraints and studying ways of overcoming challenges in exhibiting ERB for building occupants is the goal of this study. Specifically, this study focuses on the thermal aspect of ERB.

Occupant Behavior and Building Energy Consumption

Major determinants of building consumption would include building-related characteristics, and building occupant’s behavior and daily activities. The behavior and daily activities, for example, might include installing and using various electronics such as a mini fridge or computer or space heater, or adjusting thermostat conditions to suit personal comfort.

Low energy building designs have greatly benefitted the built environment, but the efforts are sometimes limited to addressing technical issues alone without considering building occupants who are direct consumers of energy. Occupants directly affect the energy performance of the buildings and are affected by the conditions created by the building's indoor environment (Steemers & Manchanda, 2010).

Social scientists (Janda, 2011; Masoso et al., 2010) suggest that limiting the energy use in buildings could require a change in the entire fabric of the society. This reveals that regulating energy efficiency might be more of a social problem than a technical one (Orland et al., 2014).

The variation in individual occupant behavior can cause large disparity in energy consumption (Wood & Newborough, 2003). The behavior of people can be hard to predict and is more complex than designers account for, as it is more idiosyncratic rather than reason-based. To suit their various needs, occupants may open windows, leave doors open, and install appliances, all of which are examples of active roles the occupants play in energy consumption, and affect the HVAC control system (Janda, 2011; Zhao, Lasternas, Lam, Yun, & Loftness, 2014). Raising awareness and education could help overcome the information deficit and correct building occupant behaviors. A common problem faced by people at home is based on the absence of explicit information regarding their consumption of energy and, so, they may have less understanding as to estimating the cost and benefits of being responsible users of energy (Janda, 2011). On average, it was found that effective promotion of energy-conscious behavior could easily reduce household electricity consumption by more than 10% by stimulating occupant behavior improvement (Z. J. Yu, Haghighat, Fung, Morofsky, & Yoshino, 2011).

Energy Performance of High Performing Buildings

A high energy performing building is designed to be self-sufficient in energy production and consumption of energy. The goal of such self-sustaining building designs, such as Net-zero energy buildings is to produce the same amount of energy that is consumed through onsite or offsite renewable energy source (Bowman et al., n.d). High performing buildings are designed to suit specifics such as the type of construction material, weather conditions, and the orientation of the building and prediction of energy consumption with an accuracy of demand. Despite the extensive planning and cutthroat technology, progression towards high-energy efficiency seems to be impeded through the failure of occupants to maximize the potential of technology installed resulting in a performance gap (Brandemuehl & Field, 2011). Equipment such as computers, printers and pantry equipment easily use almost 20% of annual energy consumption in high performing buildings, in many cases because the equipment is left plugged in even when not in use and it continues to consume energy (Masoso et al., 2010).

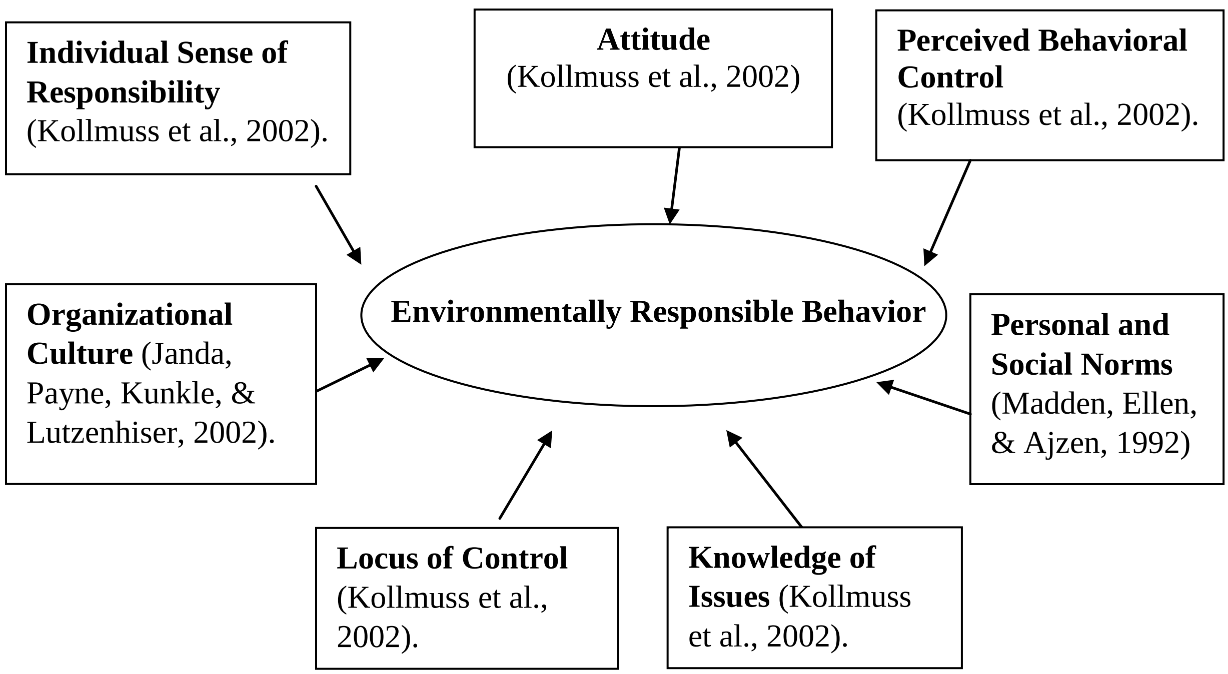
Building occupant behavior was found to be the weakest link in steps taken towards energy efficiency in high performing buildings. A large portion of the energy wasted could be attributed to compromised occupant behavior by leaving equipment turned on even when not in use (Picklum, Nordman, & Kresch, 1999). One of the common challenges faced with high performing buildings is that the cost the building faces in using a renewable energy source to power the building is quite high. For the building to efficiently use energy, the energy consumption rate should be curtailed through improved design and technology (Attia, Hamdy, O’Brien, & Carlucci, 2013). Although this effort has been made in several high performing buildings, an energy gap has been identified between estimated and actual energy consumption of the buildings and has become a recurring issue (Sartori, Napolitano, & Voss, 2012). This energy gap evidently points to the fluctuation in energy consumption caused by building occupants energy-consuming behavior, since occupant behavior can be idiosyncratic and challenging to predict (Janda, 2011).

High performing buildings are designed to be energy efficient, but it has been recently noted that the easiest way to implement a successful energy efficient building is to have zero occupants. One of the challenges faced in maintaining high performing buildings is to predict and supply accurate energy demand of the building; it depends entirely on the building occupants and their daily needs. The energy performance of the building is directly linked to the operational behavior of the occupant and adds a new challenge to accurately predict behavior. The occupants have various needs and they may respond in different ways. For example, they might open windows to improve air quality or install appliances to meet utility needs. They also generate body heat. This all means that people, not buildings, use energy (Masoso et al., 2010). The building user's behavior directly affects the internal heat gain of the building, which, in turn, affects the thermal comfort of the occupants, and, as a result, the performance of the building can suffer (Lenoir, Cory, Donn, & Garde, 2012).

Human behavior can be explained as a response to physical and psychological needs (Tabak & de Vries, 2010). Those physical and psychological needs depend highly on an individual's concern for space, light, climate conditions, acoustic needs, interaction with coworkers and office space features (Zeiler, Vissers, Maaijen, & Boxem, 2014). For instance, people tend to gravitate to resting areas while waiting to meet a friend because they would potentially present less discomfort and less stress. In this case, comfort is a determining factor of the choice (Gifford, 2011). People spend 90% of their time indoors and feeling incessant discomfort can cause a high level of distress and affect overall well-being (Oliver, 1984).

Factors of Environmentally Responsible Behavior

Based on Responsible Environment Behavior (Hines, Hungerford, & Tomera, 1987) and the Theory of Planned Behavior (Ajzen, 1991), the Environmentally Responsible Behavior (ERB) or Pro-Environment Behavior, conceptually has several factors that can affect an individual's decision to behave environment responsibly. These factors include attitude, norms, knowledge of the issue, locus of control, organizational culture, individual sense of responsibility, and perceived behavioral control.



2.1.Factors affecting Environmentally Responsible behavior (ERB)

Attitude:

An individual's attitude toward a certain behavior refers to the degree to which the person has a favorable or unfavorable evaluation of behavior in question (Whittaker, Vaske, & Manfredo, 2006). According to (Ajzen et al., 1986) attitudes are not merely related to beliefs but are functions of beliefs that lead to behavior intentions. People with strong Pro-Environmental Attitudes were found to be more likely to engage in Pro-Environmental Behavior yet the relationship between attitudes and actions proved to stand by itself. From the Theory of Reasoned Action (Ajzen, 1975) and Theory of Planned Behavior (Ajzen, 1991), it has been established that, in order to determine the correlation between attitude and behavior, the researcher would need to measure the attitude towards a specific target behavior. It has been found that people who care about the environment tend to engage in activities such as recycling and are less likely to involve themselves in activities or action that would deter the environment. Thus, there exists a high correlation between attitude and behavior (Ajzen, 1991; Diekmann & Preisendörfer, 1992; Kollmuss & Agyeman, 2002). Even though attitudes can influence ERB to a high extent, several other factors need to be considered, which have been addressed further in this chapter.

Personal and social norms:

Norms can be construed as judgments on appropriateness or standards by which an individual evaluates whether or not a behavior or condition should occur. These can be divided into social norms and personal norms (Whittaker et al., 2006). Personal norms are considered as self-regarding preferences and social norms can be referred to as behavior that an individual exhibits in order to be accepted by the social construct of people by which he or she is surrounded. This can also be specific to the social pressure that compels one to exhibit a certain behavior in order to be accepted by the reference group. A reference group is usually an individual person or a group of people that an individual interacts with on a daily basis (Bicchieri, 2010; Whittaker et al., 2006; Zeiler et al., 2014).

According to the Focus Theory of Normative Conduct (Madden, Ellen, & Ajzen, 1992), normative behaviors can be divided into descriptive and injunctive social norms (Cialdini,Reno,& Kallagrgen, 1990). Descriptive social norms can be defined as behavior that is considered as a typical or normal behavior to which most people usually conform. This can, thereby , motivate other people by providing evidence as to what would likely be an effective and adaptive action. Injunctive behavior would refer to a behavior that is morally approved conduct for an individual to display ERB (Cialdini et al., 1990; Dixon, Deline, McComas, Chambliss, & Hoffmann, 2015). People tend to compare their actions with others and derive subjective and descriptive norms from their observation about what the “proper” course of action would be. This tendency is recognized as planned behavior and the value-belief-norm model can be applied to pro-environmental behaviors or ERB (Moezzi & Janda, 2013; Humphreys et al., 2004).

Change in energy consuming behavior has a promising untapped potential for improving the energy efficiency of high performing buildings (Masoso et al., 2010). Even though building occupants tend to be a diverse group of people each having distinct differences in histories, attitudes and socio-culture, age, sex, education and income rates, social norms could direct their behavior either towards or away from exhibiting ERB and, so, is counted as a behavior altering factor.

Knowledge of the issue:

Knowledge of the issue can easily be a behavior-altering factor, as the lack of knowledge could also easily affect the behavior of an individual. For an individual to exhibit ERB, familiarity with the environmental issues, their seriousness and their possible participatory solutions would beneficial. Research has demonstrated that building occupants tend to have a knowledge gap and misconceptions about the impacts of their actions on the energy efficiency of the building (Attari, DeKay, Davidson, & De Bruin, 2010). Knowledge could bring a certain percentage of behavioral change in behavior if the occupants were made aware of the necessity of energy efficient buildings and the detrimental effects to the environment of high-energy consuming buildings. Education that goes beyond mere awareness of energy consumption rates and incorporates a more comprehensive, integrated, hands on and iterative approach could incline an individual to exhibit ERB (Attari et al., 2010; Casado-Mansilla, López-de-Armentia, Ventura, Garaizar, & López-de-Ipina, 2016; Janda, 2011)

Ignorance can easily be a barrier since not knowing that a problem exists or not knowing what to do once one becomes aware of the problem can inhibit the display of ERB. A proportion of the global population may not be likely to take deliberate actions towards furthering energy efficiency because of various reasons, some of which could be attributed to lack of knowledge. Although the majority of people are aware of the need to be energy efficient, there is still a lack of knowledge in relevant, energy saving actions that can be taken in the effort to be environmentally responsible (Gifford, 2011).

Locus of control:

This represents an individual's perception of whether he or she has the ability to bring about change through his or her own behavior in exhibiting ERB. People with a strong internal locus of control believe that their actions can bring about change. On the other hand, people with an external locus of control tend to feel that their actions are insignificant and that change can only be brought about by a group effort. In regard to ERB, one can make rational, analytical assessments of the likelihood of a possible outcome and arrive at a calculated decision that proceeds in the form of an action. These decisions affect a person's positive or negative feelings about specific objects, ideas and emotions. Several studies conducted in the past concluded that a person's choices are based on knowledge derived experientially, which, in turn, is more compelling and likely to influence their ERB (Leiserowitz, 2006).

Organizational culture:

Since each organization would have their own beliefs and priorities in regards to building occupants ERB, the organizational culture could be a behavior-altering factor. Energy efficiency in a commercial setting would require a group effort to arrive at a considerable cutback on energy consumption. An individual's investment in energy conservation can vary from organization to organization based on that organization's recognition of individual's efforts towards energy efficiency and the social norm that it sets as conditions and beliefs (Janda et al., 2002). Providing feedback about the amount of energy used by each individual consumer can effectively help building occupants take steps towards being environmentally responsible for keeping track of real-time energy consumption level (Casado-Mansilla et al., 2016)

Individual sense of responsibility:

People who have a greater sense of personal responsibility are more likely to have engaged in ERB. Barriers to exhibiting ERB include one's individuality, ownership of responsibility and acceptance of practicality toward taking steps to be environmentally friendly. Barriers related to one's individuality lie within internal variables that include attitude and temperament. Blake suggests that responsibility would be very close to psychologists' notion of locus of control. The reason some people do not act pro-environmentally could be because they do not feel they can influence the situation alone or take full responsibility for energy efficiency. As a mere individual in the midst of the entire group of building occupants, they may feel they do not have control to curtail the effects on a large scale and therefore choose not to contribute to any ERB (Kollmuss et al., 2002).

Perceived Behavioral Control (PBC):

A person's perception of ease or difficulty in performing the behavior of interest can be defined as Perceived Behavioral Control (PBC) (Ajzen, 1991). PBC can be a very strong predictor of environmentally friendly choices such as taking public transportation instead of driving a private car. Lack of individual PBC or the sense of a lack of ability to accomplish a specific task (self-efficacy) leads to fatalism, which is a sense that nothing can be done by the individual but only a by collective human action (Gifford, 2011).

PBC may often accurately reflect the availability of resources and opportunities, and result in influencing both PBC and actual behavior (Ajzen et al., 1986). Some internal factors specific to an individual's perception of control include one's skills, abilities, knowledge and adequate planning, while some examples of external factors would be time, opportunity and dependence of behavior on the cooperation of other people. In order to assess the accuracy of predicting an individual's behavior, the individual's capability to exercise control over the behavior in question must be added to these factors (Ajzen et al., 1986). Given the possibility of the direct connection between PBC and general behavior, it has been noted previous studies that occurrence of a behavior depends on motivation for the behavior along with adequate perception control and individual experiences. This, in turn, affects the behavioral intentions of an individual thereby affecting actual behavior (Kaplan, 2000). People feel better and tend to be in a more relaxed and stable mental state when they can control their surroundings. However, when opportunities for control over one's indoor environment are thwarted, a feeling of 'helplessness' could result (Humphreys et al., 2004). The inclination in established psychology is to treat control as the opposite of helplessness, and it can be assisted by making provisions for building occupants to feel satisfied and empowered (Kaplan, 2000). For instance, noise can be an example of an uncontrollable stimulus that can be a distraction while performing a task.

Barriers to building occupants exhibiting Environmentally Responsible Behavior (ERB)

ERB is said to occur when an individual or group of individuals aims to do what is right to help protect the environment by taking steps in general daily practices. Such actions could also be referred to as pro-environmental behavior, Environmentally Friendly Behavior, Stewardship Behavior and Conservation behavior (Mobley et al., 2009). Even though people maintain a positive attitude, they still may not engage in a certain ERB because of the lack of opportunity. Ajzen et al., (1986) found that constraints towards ERB prevent an individual from exhibiting a positive attitude toward the environment if they experience hindrance in expressing themselves. Research on PBC suggests that a high probability of engaging in ERB would require individuals to be more likely to engage in pro-environmental behavior if they believe they have the ability to mitigate environmental problems through their behavior (Tanner, 1999; Kyle et al., 2012).

Buildings differ from each other in a number of ways including physical forms of heating and cooling systems and the possibility of the occupants controlling their environment. Certain aspects of the building services, especially in regard to comfort, prove that when the occupants tend to have more control they exhibit more ‘‘forgiveness” (Humphreys et al., 2002).

Forgiveness refers to the attitude the occupants in the building have in regards to their comfort condition, and says that they learn to overlook shortcomings in the thermal environment more readily. Variability in thermal conditions is perceived to be a bad thing in centrally controlled buildings because occupants are adapted to a particular temperature. Any deviation from this can become uncomfortable, as it requires the body to continuously adapt itself to its surroundings. In buildings where occupants are in control, variability may result from people adjusting conditions to suit them. Such control could alter the energy consumption rate because of the constant change in thermostat conditions (Humphreys et al., 2002).

A certain amount of variability then becomes a "good thing." Another option would be to leave control to the building manager through the HVAC system, but then there is a smaller envelope of acceptable conditions as comfort changes more quickly with temperature, and the occupants become less forgiving. "Adaptive opportunity" can be interpreted as the ability to open a window, draw a blind, use a fan and so on, but must also include other external control factors such as dress code in the work place, the job description and working practices. Working practices include the number of hours an individual spends in front of a computer along with other factors that influence the interaction between building occupant and the building itself. Adaptive opportunity is not necessarily restricted to temperature controls, however. The mere inclusion of controls, although providing an opportunity for the building occupant to exhibit control, does not therefore give a good measure of the success of a building or improve its adaptive opportunity (Humphreys et al., 2002).

Effect of Perceived Behavioral Control over Thermal Comfort

Individual sense of comfort:

Thermal comfort can be construed as a state of mind where a person expresses satisfaction with the thermal environment (Olesen & Brager, 2004). A person's sense of thermal comfort is a result of the body's heat exchange with the environment and is affected by the air temperature, radiant temperature, humidity and air speed along with two personal parameters: clothing and activity level/ metabolic rate. To simplify the process of achieving comfort, *ASHRAE* Standard 55 has traditionally defined an acceptable thermal environment as one in which there is 80% overall comfortability with thermal conditions and 10% dissatisfaction under each category. According to Olesen et al.,(2004) the best way to improve the level of comfortability may be through the adaptive approach, which suggests e that the variability in indoor temperatures may be caused by actions that reduce discomfort for other occupants in the effort of increasing one's own comfort. In a situation where there was no possibility of changing clothing or activity and where air movement is not used, the comfort zone can be narrow as 2 degrees Centigrade. Changes in clothing, activity and posture, and the promotion of air movement can alter conditions so they may feel more comfortable (Humphreys et al., 2002). A qualitative analysis revealed that a lack of comfort was the main behavioral barrier for people who desire energy efficient behavior (Gerdenitsch, Schrammel, Döbelt, & Tscheligi, 2011).

Several factors potentially influence personal comfort. This includes demographic factors, external factors (institutional, economic, social, and cultural factors) and internal factors (motivation, environmental knowledge, awareness, values, attitudes, emotion, locus of control and priorities). A valid argument could be made that environmental knowledge is a subcategory of environmental awareness and the emotional attitude. Kollmuss et al.,(2002) has addressed various decision-altering factors but failed to include other factors such as comfort and convenience. There are many competing factors that shape daily decisions and inspire actions toward a pro-environmental behavior. The pro-environmental consciousness is a complex concept comprised of environmental knowledge, values, and attitudes, along with emotional involvement. This complex model is embedded with broader personal values and shaped by personality traits and other external factors. Feelings of responsibility are shaped by one's values and attitudes and are easily influenced by one's locus of control. Prioritizing personal well-being and the well-being of family members would help align personal priorities (Kollmuss et al., 2002).

The surrounding built environment directly affects the psychology of individuals by linking people's comfort to their actions through the adaptive principle toward the comfort temperature. The comfort temperature is a result of the interaction between the subjects and the building or other environment occupied. The fundamental assumption of the adaptive principle is that if a change occurs such as to produce discomfort, people react in ways that tend to restore their comfort. Providing options for people to react and reflect on their surroundings gives them more opportunities to adapt to the environment or for the environment to mold requirements that help them experience less discomfort (De Dear et al., 1998).

Adaptive sense of comfort:

People seem to be more tolerant of conditions when more control opportunities are provided to the occupants in the form of switches, blinds and opening windows. People tend to be more forgiving of discomfort if they have some effective means of control to alleviate the discomfort. It is widely acknowledged that people who have a high degree of control over a source of discomfort are able to tolerate wide variations, are less annoyed, and can thwart any negative emotional responses. When a person has been offered an opportunity of choosing their sitting positions with the choice of both the sun and the shade open to them, individuals moved positions because of discomfort, and the availability of choice improved the attitude toward the situation. One study showed that 23% of people using the space as a meeting place while waiting for someone to arrive reported dissatisfaction with the environment. However, the amount of dissatisfaction decreased by half when people had a personal choice of whether or not to leave the space (Leaman & Bordass, 1999).

Most energy efficient buildings take away control from people and replace it with automatic control systems that govern the overall indoor environment and deny the occupants any means of intervention. There is an important difference between comfort provision and discomfort alleviation. Most control adjustments are made at the onset of discomfort, triggered by something experienced as uncomfortable, rather than in anticipation of discomfort. Since spaces in offices with fixed control systems give building occupants little or no user control, there is a difference between tolerable comfort and dissatisfaction (Leaman et al., 1999).

The environmental aspects of comfort include ambient environmental conditions such as noise, lighting, air quality, thermal comfort, and furniture layout including workstations, offices and shared amenities. Numerous fields of study point out that people need to be comfortable more so than simply healthy and safe in the space occupied (Vischer, 2008). Functional comfort goes beyond the most traditional concept of comfort based on measurement of user response to varying environmental conditions. Functional comfort links psychological aspects of a worker’s environmental likes and dislikes with concrete outcomes measuring task performance and team effectiveness. The design of the workspace reflects not only how people feel but also influences their work performance, their commitment to their employer and the creation of new knowledge in the organization. A measure of user perceptions of environmental conditions can be used to diagnose building performance and effectiveness of building systems (Vischer, 2007). The user is not a passive receptacle experiencing the built environment. Functional comfort as mentioned previously refers to the degree to which the environment supports the user's tasks. At a more abstract level, but equally important to workers, is psychological comfort, which includes feelings of belonging, ownership and control over one's workspace (Vischer, 2008).

All occupied buildings are designed around explicit or implicit assumptions about user behaviors, decisions and responses. People both effect and are affected by the built environment, but their role in the built environment is most often ignored (Manchanda et al., 2010). From an environmental psychological perspective, whether or not a building is successful in promoting a positive occupant behavior depends on the accuracy level of behavior prediction. The amount of energy consumption depends on the behavioral choices that would either increase or decrease the rate of energy efficiency of the building. Behavioral decisions consummate in actions that determine the amount of water and energy consumed by the building as well as with the amount of liquid and solid waste generated by the building in washing dishes, taking showers, turning lights on and off and using other energy consuming gadgets (Wener & Carmalt, 2006).

The ability of a person to control his or her environment has a significant impact on occupant satisfaction. This control can be achieved by localizing the building occupant and automatically conditioning his/her workspace, and having the possibility to adjust the user's environment. Prioritizing the needs of the occupants in the building and including them as a factor in determining energy efficiency is critical in preventing discomfort and promoting energy consuming behavior to restore comfort (Zeiler et al., 2014). Approaching energy efficiency with a human perspective and using the availability of new technology to better understand the critical aspects of the comfort of the end users results in about 20% energy saving in heating demand and 40% energy savings in cooling demand (Zeiler et al., 2014).

Building Design and Workspace Features, Psychology of possession, also called ownership, results from a sense of responsibility, and past research suggests that the feeling of possession creates a sense of responsibility that influences behavior (Van Dyne and Pierce 2004). When individuals have possessive feelings, they proactively enhance control over the environment. At the same time, they protect both tangible and intangible targets of ownership. Psychological ownership addresses three basic human needs such as sense of place, efficacy and motivations and self-identity. Feelings of psychological ownership through attachment to a place or an object make that place become a home for an individual because of a sense of belonging. In order for a person to feel belonging to a physical structure, he or she must orient their lives around possession of the structure. That, in effect, can satisfy their pressing psychological need for belonging and ownership through attachment (Whitmarsh, 2009).

The concept of 'work-space' originated from an environmental analysis that incorporated both the functional and psychological meaning of space. A workspace is defined as a physical space designed and used for a specific set of activities, creating an integral relationship between one's work and the space in which an occupant completes his or her work. The user can, therefore, be seen as managing his or her relationship with the workspace. This is a cognitive mechanism of spatial orientation and place identification, as one does work and feels secure according to an affective reaction, either positive or negative and translating into satisfaction or dissatisfaction (Fischer, Tarquinio, & Vischer, 2004).

Professionals and practitioners such as builders, contractors, architects and energy service providers are the ones who define the parameters for the possibility of enabling energy conservative behavior for the building occupants. Implementing structural changes can be important starting points that could even potentially change the workflow procedures and product use toward greater productivity and efficiency (Dixon et al., 2015). Many times, neither the ones who design the building nor those who build it actually use the building. Rather the building occupants do. Therefore, including them in an earlier stage of a construction project rather than on a later finished product could improve the satisfaction level of those occupants. It has been noted that building users consistently overturn actions in response to uncomfortable conditions resulting in an unnecessary reversal that can waste energy and create an uncomfortable environment. Further, occupants tend to adjust their surrounding environment in order to reach at least their minimum comfort needs (Zeiler et al., 2014). The correlation between knowledge, comfort, and frequency of control use was investigated and it was found that virtually no correlation exists between knowledge and frequency of control. It seems that the less comfortable inhabitants of a building are, the more they are prone to use personal controls available to them. However, it was also noted that, because of slow and ineffective controls and lack of meaningful and effective feedback on consequences of their actions, the building users became more frustrated and their comfort consequently decreased. A counter-effect of personal control provision and use challenges design assumptions regarding the impact of personal control provision and use of challenge (Brown, 2009). The environment of the physical workplace directly affects the employee's satisfaction, his/her productivity, and well-being. Having a functional comfort level that envelopes factors such as adequate lighting, flexible and adaptable furniture, along with psychological comfort promotes a feeling of control over one's environment and increases the productivity of an employee (Agha-Hossein, El-Jouzi, Elmualim, Ellis, & Williams, 2013).

Studies (Newborough et al., 2003) have shown that energy consumptions can be reduced by providing the consumer a more informed choice about their energy-using practices. Change in energy-using behavior has a promising potential for energy conservation. The building occupant population includes a diverse group of people each having distinct histories, attitudes and socio-cultural demographics including age, sex, and education and income rates. Therefore, a person in the building population shows differences in his or her physical and mental health and relationships with family and friends that can affect energy-use behavior as well as the ability to carry out proven energy saving techniques. Therefore, methods for reducing the population's energy consumption must account for a wide array of demographic differences and function effectively despite these differences. For example, demographic differences may influence whether a building occupant in a residential building keeps some appliances such as the refrigerator, TV's, VCR's turned on while he or she is sleeping, which impacts how much electricity is consumed (Newborough et al., 2003).

Considering energy use from a social perspective rather than a technical one offers an opportunity to rethink energy use. Social and behavioral scientists have worked in the energy efficiency industry with the goal of focusing on new ways to get individuals to change behavior. Energy use feedback in particular has been postulated as potentially creating a major change in the way individuals think about energy use. Though less formal than technical changes, the idea that there is untapped behavioral energy savings potential has helped, inspire and justify policy and research toward changing individual behavior. Programs that aim to promote energy efficiency typically provide individuals with information expecting it would inspire change toward lower energy use (Moezzi & Janda, 2013).

Need for Research

As the previous discussion implies, there is a need to better understand the relationship between building occupants' PBC and their ERB. Achieving higher energy efficiency in high performing buildings through ERB has been a challenge and many different approaches can be taken to encourage ERB. Prior research has shown that the actions of a building occupant can be either encouraged or restricted by physical constraints placed in the building occupant's workspace. These physical constraints, both directly and indirectly, affect occupants' perception of control. Every building occupant feels the need to be comfortable, both physically and psychologically, in their workspace. Occupants' level affects the degree to which they exhibit ERB. Providing PBC for building occupants might be the answer to higher functional energy efficiency. However, most high performing buildings tend to overlook this and, instead, try to centralize thermal control to avoid fluctuations in energy consumption. The following chapter gives a detailed explanation of the research methods used to investigate and determine the correlation between ERB and PBC regarding thermal conditions, specifically in educational office buildings at CSU.

CHAPTER III

RESEARCH APPROACH

Past research indicates that individual behaviors can ameliorate or exacerbate energy consumption in a building (Janda, 2011; Masoso et al., 2010 ; Z. Yu, Fung, Haghighat, Yoshino, & Morofsky, 2011). Environmentally Responsible Behavior (ERB) can be defined as behavior that enables conservation of one's environment by taking steps to be more environmentally friendly (Mobley et al., 2009). For the sake of this study, the Environmentally Responsible Behavior (ERB) is limited to the energy consuming behavior that a building occupant exhibits within their working environment inside their building. Based on behavior studies conducted by Ajzen (1991), the behavior of an individual can be seen as the outcome of an individual's attitude, the social norms they experience, their personal beliefs and values, and their Perceived Behavioral Control (PBC). Building features and workspace environments could provide improved PBC for the building occupants if these human factors are considered and incorporated into both the building design and operational phases. The following chapters describe a detailed study, which aims to determine the correlation between PBC and ERB.

Method of Data Collection

The survey used for this study was distributed through an online software Qualtrics and was distributed to a sample of academic office buildings through an online link. A survey method chosen was to distribute the surveys to building occupants in a high energy performing building for data collection since as no one else could explain their perceived behavioral control other than the occupants themselves. Consistent and demographic questions were built into the survey so that comparison of responses among various groups could be facilitated.

The survey was developed and distributed to all building occupants within carefully chosen buildings with the objective of understanding the correlation between ERB and PBC, especially with regard to thermal conditions. Thus the survey helped record self-reported behavior (Dixon et al., 2015), specifically behaviors that would affect the energy consumption level in the building, along with the perception of control the individuals experienced.

Survey Development

The survey questions and format used for this study was constructed based on preexisting survey (Karatas, Stoiko, & Menassa, 2016) that have been used in the past to determine the display of ERB. In addition, the survey questions included considered the concepts learned from a detailed literature review given in Chapter 2. The survey instrument was reviewed by expert research professionals in both fields of construction and sociology. Their feedback was incorporated into the survey instrument before it was piloted.

Pilot Test

A pilot survey of the survey's questions and structure was distributed among occupants of two buildings at Colorado State University main campus in Fort Collins, Colorado in November 2015. The two buildings were Palmer Center and Centennial Hall, both of which primarily serve as commercial office buildings. The survey yielded 93 responses, out of which 83 were complete responses. Based on the pilot survey, certain questions were revised to reduce the survey length and to improve question flow.

Survey Distribution

The final survey was distributed in two buildings at Colorado State University: the CSU Powerhouse and the Scott Engineering Building.

CSU Powerhouse:

The CSU Powerhouse is located in the Powerhouse Energy campus in Fort Collins, Colorado. The building received its LEED Platinum certification in 2015 energy complex and is home to numerous research centers. The building has active daylight harvesting installed with 100% day lighting. Heating is provided by a condensing boiler system using variable speed pumps. Fiberglass window frames are included on all windows, and large curtain walls offer high insulation. The building uses sensors for light switches and is comprised of large open-spaced offices. The building bears the LEED platinum plaque at the building entrance ensuring that all occupants are aware of the energy efficient goals for the building. The respondents to this survey were limited to the building occupants alone. The survey was distributed to the all building occupants through the building proctor. This ensured the all occupants received the survey link and had an opportunity to complete the survey.

Scott Engineering Building:

The Scott Engineering building is located in CSU main campus; it is a 122,000 square foot interdisciplinary research and academic facility for the College of Engineering at CSU. The building was designed to meet LEED gold and includes energy efficient building features. The survey was distributed with the help of the building proctor. The response rate from the Scott Engineering building was only 13 occupants. Because of so few responses, the data was not analyzed because the sample size would have restrained any statistical significance.

Survey Sections:

The surveys were distributed to CSU Powerhouse Energy campus and the Scott Engineering Building through the building proctors of each building, with the hope of reaching building occupants that held a workspace in the building. The survey instrument can be broken down into five sections: Demographics, Workspace Location, ERB, PBC over one's thermal conditions and Building Design Features. Section breaks were included so that it would provide the survey respondents with the ability to easily follow and maintain the thought process while answering the survey, which would reduce any respondent burden.

Demographics:

This section was the first section in the survey to understand the respondent's background. Specific factors sought in this sequence of demographics included age, gender, and the number of years spent in one's workspace and location of one's workspace in the building.

Workspace location:

The workspace location in a building is the part of the building that each building occupant closely interacts with and by which he/she is daily affected. When an individual desires to act environment responsibly, the lack of appropriate infrastructure or lack of cultural support could impede the desire to act in a manner of daily ERB (Kaplan, 2000). The workspace can become a stressor impeding one's comfort level and can affect the behavior of an individual. These set of questions that come under the workspace and building features section were included to understand the reasons behind a building occupant's behavior to better assess his or her views on their individual workspace conditions. The location of the respondent in the building was determined by using a heat map to point out the location of their workspace in the grid pattern provided over the building layout.

Questions asked in this section included the following (Karatas, Stoiko, & Menassa, 2016):

- Which of the following best describes your workspace? (Enclosed-private, enclosed-cubicles, -cubicles-high partitions, cubicles-low partitions)
- Do you share your primary workspace with others? (No, Yes (shared with 1, shared with 2-4 others, shared with 5-8 others, shared with more than 8 others)
- Is there any design feature you would change about your workspace overall?

Environmentally Responsible Behavior (ERB):

Environmentally Responsible Behavior (ERB) in this study refers to the behavior a person exhibits in the effort to reduce the energy consumption level to the best of his or her ability in the workspace and work environment, specifically his or her building (Mobley et al., 2009). By recording the self-reported behavior of an individual, ERB was identified. Survey questions in this section were carefully framed to determine the frequency at which the building occupants exhibited energy-consuming behaviors. Some questions related to a building occupant's comfort level and ways of adapting and mitigating to regain the lost comfort level were presented in this section. A respondent could choose either from an energy responsible behavior or an energy consumptive behavior based on a self-reported assessment of his or her own behavior. The survey questions in this section were mostly closed-ended on a bipolar scale including a neutral point and two opposite ends of the scale to determine interval level. The questions included a scale response between 1-to-5 rating in which the respondents could choose from Strongly Disagree, Disagree, Agree, Strongly Agree, and Not Applicable (Creswell, 2013; Vaske, 2008). The following questions from (Karatas, Stoiko, & Menassa, 2016) were included in this section:

- When your office is too chilly, what do you do?

  - Wear a thick layer
  - Use a space heater
  - Turn up the heat by adjusting the thermostat
  - Drink a hot beverage
- When your office is too warm, what do you do?
  - Open the windows
  - Wear a light layer of clothing
  - Turn down the thermostat
  - Drink a cold beverage
  - Use personal cooling equipment
- When you leave, the windows open in the office how often do you adjust the thermostat to use less heating/cooling?
- When you leave the office in the winter how often, do you adjust the thermostat settings to decrease your temperature?
- When you leave the office in the summer, how often, do you adjust thermostat settings to increase your temperature?

PBC- Thermal comfort:

This study specifically focuses on the thermal conditions of PBC a building occupant experiences. PBC in this study can be defined as the perception of control over one's surrounding thermal conditions, that provides an individual with a perception of potentially acting environment responsibly, hence encouraging ERB (Ajzen et al., 1986). PBC being an dependant variable of ERB in this study, affects whether or not a person chooses to exhibit Environmentally Responsible Behavior (ERB). With this in mind, survey questions have been developed to determine whether the building occupants perceived control over the temperature in their workspace. These survey questions also included a scale response between 1-to-5 rating, and the respondents could choose from Strongly Disagree, Disagree, Agree, Strongly Agree, and Not Applicable based on the assessment of their behavior (Creswell, 2013; Vaske, 2008).

The following questions from (Karatas, Stoiko, & Menassa, 2016) were included in this section:

- I always control temperature at my workspace to meet my needs
- I often alter the main thermostat conditions in my office space to suit my comfort needs
- I dislike the lack of control of heat and light in my immediate proximity

Building design features:

Professionals such as architects, engineers, contractors and energy providers are the ones that set the parameters for the possibility of enabling energy conservation behavior for building occupants. This points to the high importance of the building and its features as they can either impede or promote ERB (Zeiler et al., 2014). To help understand the perception the building occupants have toward the building in which they work, the following questions (Karatas, Stoiko, & Menassa, 2016) were presented to the respondents.

- Is there any design feature that you would change about your building overall?
- Is there any design feature that you would change about your workspace overall?

Human Research Approval

The survey for this study was sent to the Research Integrity & Compliance Review Office's Institutional Review Board for approval. Since the study maintains confidentiality and was considered to be of minimal risk to respondents, it was exempt from the requirements of human subject's protections regulations in 45 CFR 46.101(b)(2). See Appendix B.

Data Analysis Method

Nominal, ordinal and scale data was collected from the survey instrument that would lead to drawing a range of descriptive statistics to examine frequencies, mean and distribution. The scales are planned to computed separately for both ERB and PBC regarding thermal conditions based on survey responses. SPPS software was used to run correlations. Reliability tests were conducted within each scale for the multi-item indicators for ERB and PBC over one's thermal conditions. The Measurement reliability is a test for the internal consistency of the responses that will form scales for both ERB and PBC specifically constructed to measure these predetermined concepts. Here the concepts are ERB and PBC over one's thermal conditions (Ajzen et al., 1986).

The Cronbach's alpha value was used to assess internal consistency for each scale to verify the reliability of the scale. The Cronbach's alpha is a commonly used estimate of internal consistency of items in a scale specifically estimating the proportion of variance, which is consistent with a set of survey responses. A One-way analysis of variance (ANOVA) was used as the research method to study the correlation between ERB and PBC using the multi-item indicator that comprises of the survey questions. Indices were developed for both ERB and PBC using those indicators that showed high internal consistency. Bivariate Pearson correlations were also performed between ERB and PBC. The findings are presented in Chapter IV.

CHAPTER IV

FINDINGS AND ANALYSIS

Data for this study was collected via an e-survey (see Appendix C). The questions in this survey instrument, both open-ended and close-ended, were selected to serve as indicators to help measure ERB and PBC in regard to thermal condition of building occupants in high perfroming buildings. The analysis presented in this chapter was carried out with the goal of understanding the affect of various influencing factors of daily ERB and PBC experienced by building occupants regarding thermal conditions. The open-ended responses are analysed through a qualitative method to gain a deeper understanding of the effect the various building design features have on the comfort of its building occupants.

Survey Results

Response rate:

Respondents of this study include building occupants working in a LEED certified, academic office building. The e-survey instrument was distributed through the building manager with the intention of reaching all the building occupants. High-energy performing buildings were targeted in order to identify the reasons behind an energy responsible behavior. Specifically, the survey was distributed to the Powerhouse Energy campus of Colorado State University (CSU) and the University's Scott Engineering Building. Thirteen responses were received from the Scott Engineering Building and the survey drop rate was 100%, the reason for this drop rate could be that the Scott Engineering building mainly comprises of classrooms and some faculty and graduate student office spaces which implies lower opportunity of regular academic office spaces . Therefore, the data of these respondents were not analysed because of an insufficiency to yield any meaningful results.

The Powerhouse includes approximately 75 to 100 primary building occupants. The number of responses received was 40, out of which 38 respondents completed the entire survey and gave responses that could to be analysed. Therefore, this group of responses became the survey sample for this study. The response rate is estimated to be 50%, assuming the number of building occupants as between 75. The survey was sent to all building occupants with a workspace in the building. In addition, open-ended questions allowed collecting commentaries from occupants about their likes and dislikes related to the building and its design features. This provided more understanding of the building occupants' perceptions and the underlying reasons for their responses. The survey was open for a two-week period, after which it was closed and deactivated.

Demographics:

Demographical information for this study is important, as various factors can affect a building occupant's behavior and perceived control over one's environment. These factors include age, gender, and workspace location in the building. The demographics presented in the following table provides context to the responses received in the remaining sections of the survey.

Table 4.1 Consolidated Demographics

Demographic	Characteristic	n	%
How many years have you worked in this building	Less than 1 year	6	15
	1-2 years	19	47.5
	3-5 years	8	20
	More than 5 years	6	15
How long have you been working in your present working space	Less than3 months	3	7.5
	7-12 months	11	27.5
	1-2 years	21	52.5
	More than 2 years	4	10
In a typical week, how many hours do you spend in your workspace	10 or less	3	7.5
	11-20	6	15
	21-30	6	15
	31-40	17	42.5
	More than 40	7	17.5
What is your age	18-24	7	17.5
	24-30	15	37.5
	34-44	11	27.5
	45-55	5	12.5
	Over 55	1	2.5
What is your gender	Male	26	65
	Female	12	30
	Prefer not to respond	1	2.6
Is your office desk located near an exterior wall within 15 feet	Yes	26	62
	No	13	32.5
Is your primary work area near a window	Yes	27	69.2
	No	12	30.8

Based on the survey data collected in Table (4.1), it can be seen that 47.5% of the building occupants have worked in the building between one to two years, this implies that most building occupants have spent enough time in the building to assess its comfort level. Data in Table (4.1) shows that the building occupants comprise of more men than women. This poses a possibility of different temperature needs of men and women having different levels of temperature comfort, gone met and unmet due to gender reasons.

Data in Table (4.1) shows that 62% of the respondents have their desks located at close proximity to an exterior wall and 69.2% of the respondents have their primary workspace close to a window. These high values can be a result of the open floor plan that has private office spaces located along the curtain wall bordering the edge of the building.

Environmentally Responsible Behavior:

In this section of the survey, self-reported behavior was measured using a Likert scale to indicate the frequency of performing a certain behavior ranging between 'Strongly Agree', 'Agree', 'Disagree' and 'Strongly Disagree'. The scale also included other options such as 'Never', 'Rarely', 'Sometimes', 'Often', 'All of the time' and 'I do not have control' in some other questions. The Likert scale provides flexibility for building occupants to choose the option closest to their daily behavior. ERB measures whether or not a building occupant's behavior increases or reduces the consumption of energy in the building through his or her choice of daily activities.

Table 4.2 Building occupant's response to feeling chilly in the office

Question	*Strongly Agree*	*Agree*	*Disagree*	*Strongly Disagree*	*N*
Wear a thicker layer of clothing Q(61_1)	25	12	1	0	38
Use a space heater Q(61_2)	5	4	5	12	26
Turn up the heat by adjusting the thermostat Q(61_3)	1	2	1	11	15
Drink a hot beverage Q(61_4)	10	18	7	1	36

The first question in this section asked building occupant about their thermal comfort in their office space. From Table (4.2), it can be seen that around 65% (n=25) respondents strongly agree to wear a thicker layer of clothing as response to feeling chilly in the office and only one respondent strongly disagrees with the statement. A low response of 13% (n=5) was received for use of space heaters in occupants' workspaces. This could be due to lack of provision of outlets in one's office space or the building officials and facility managers discouraging the use of space heaters in personal office space.

Fifteen participants responded to the question regarding turning up the heat by adjusting the thermostat. One respondent strongly agreed, two agreed, one disagreed with the statement and 11 strongly disagreed with the statement. Since 73% (n=11) respondents strongly disagreed with this statement, this suggests a possible conclusion that the frequency of improving one's thermal comfort by adjusting the thermostat is low due to either a lack of thermostats in the building or a lack of access to thermostats.

Thirty-six respondents expressed their opinion on drinking a hot beverage when they felt cold or chilly. Of these, 10 strongly agreed, 18 agreed, seven disagreed and one strongly disagreed. These responses suggest that the most building occupants alleviate their discomfort of feeling chilly by drinking a hot beverage which would be 77 percentage.

Table 4.3 Building Occupant's response to feeling warm in one's workspace

Question	*Strongly Agree*	*Agree*	*Disagree*	*Strongly Disagree*	*N*
Open the windows Q(62_1)	10	14	4	0	28
Wear a lighter layer of clothing Q(62_2)	16	20	1	0	37
Turn down the thermostat Q(62_3)	1	3	4	7	15
Drink a cold beverage Q(62_4)	15	17	2	1	35
Use a personal cooling equipment Q(62_5)	4	3	4	10	21

Table (4.3) shows results from another question used to determine the ERB of the building occupants, namely how one responds to feeling warm at work. From table (4.3) it can be seen the total number of responses to whether the individual drinks a cold beverage when the office is too warm was 35, out of which 42% (n=15) respondents strongly agreed with the statement, 48% (n=17) agreed, two disagreed and one strongly disagreed with the statement. This helps support the responses received in the previous Table (4.3) regarding drinking a hot beverage. The results suggest that drinking either a hot or a cold beverage, depending on the situation, helps alleviate thermal discomfort in one's workspace.

Also from Table (4.3), a total number of 28 respondents responded to whether or not they open windows when they feel warm, out of which 35% (n= 28) strongly agreed with the statement, 50% (n=14) agreed to the statement, four disagreed and seven strongly disagreed. Based on responses received about the location of one's workspace in the building, most respondents said their workspace is located away from an exterior wall. Thus, most respondents do not have easy access to open a window.

Table 4.4 Frequency in which the Thermostat is changed to suit-building occupant's needs (n=37)

Question	*Never*	*Rarely*	*Sometimes*	*Often*	*All of the time*	*I do not have control over the thermostat*
When leaving the office in the winter, how often do you adjust thermostat settings to decrease your room Q(34_6)	9	2	1	0	1	24
When leaving the office in the summer how often do you adjust the thermostat settings to increase Q(34_7)	7	3	1	1	0	25
When leaving the windows open in the office how often do you adjust the thermostat settings to use less heating/cooling Q (59)	33	2	2	0	1	-

Table (4.4) shows three additional questions used to understand the ERB of the building occupants. Thirty-seven responses were received for the question of how often one adjusts the thermostat settings to decrease the room temperature when leaving the office in the winter. A majority of respondents 64% (n=24) expressed that they do not have control over the thermostat, nine respondents expressed that they never adjust the thermostat, two acknowledged that they rarely turn down the thermostat, and no responses were received for "often turning down the thermostat".

The number of responses received for the question of whether one adjusts the thermostat to increase temperature when leaving the office in the summer was also (n=37). In this case, 71% (n=25) expressed that they do not have control over the thermostat, seven (7) respondents reported never altering the thermostat, three (3) responded that they rarely alter the thermostat, one (1) individual admitted sometimes adjusting the thermostat, and no respondents said they often alter the thermostat.

Table (4.4) also depicts the respondent's action on adjusting the thermostat settings to compensate for a window being open. Based on the results, 87% of the respondents (n = 33) never adjust the thermostat when the windows are open, two respondents sometimes adjust the thermostat to use less heating or cooling when the window is open, and no respondents adjust the thermostat often to use less heating or cooling when the window is left open. Curiously, one respondent reported that they always adjust the thermostat settings to use less heating or cooling when the windows are open even though there is no control over the thermostat experienced by building occupants. Table (4.4) confirms the issue proposed earlier that most respondents do not have any control over the thermostat and, thus, are not often adjusted by the building occupants to improve their thermal comfort level. This lack of control possesses an issue for the type of analysis that was originally planned to be conducted by correlating PBC and ERB.

Perceived Behavioral Control:

The questions in this section measure the PBC of buildings occupants regarding their ability to adjust conditions in their workspace to improve their thermal comfort level. Table (4.5) shows the responses received for three statements that help understand the degree of PBC to thermal conditions experienced by building occupants. As before, Likert scale responses were used and included: Never, Rarely, Sometimes, Often, All of the time and I have no control.

Table 4.5. Building occupant's control over the Thermostat (n=37)

Question	*Never*	*Rarely*	*Sometimes*	*Often*	*All of the time*	*No control over the thermostat*
I always control the temperature at my workspace to meet my needs (Q34_2)	9	4	1	1	0	22
I dislike the lack of control of heat and light in my immediate proximity(Q34_4)	8	11	6	5	5	2
I often alter the main thermostat in my office space in order to suit my comfort needs(Q34_5)	11	2	0	0	0	24

The statement "I always control the temperature at my workspace to meet my needs" had 37 responses, of which 59% (n=22) said they did not have control over the thermostat. These responses align with the low frequency of control the building occupants experience over the thermostats. Nine respondents said that they never control the temperature in the workspace, four responded saying they rarely control the temperature in the workspace, one respondent sometimes controls the temperature, and one person always controls the temperature in his or her workspace to meet his or her comfort needs.

Twenty-four respondents out of 37 respondents in Q (34_6) have acknowledged a lack of control experienced over the thermostat Table (4.5). This result accounts for 64% of the total respondents. When the responses for (Q 34_7) are analysed, it can be seen that 25 respondents out of 37 claim to have no control over the thermostat. These results directly reflect the features of the building regarding control the occupants have over the thermostat. The lack of control by building occupants have over the thermostat poses a challenge to this study, since the focus of this study was to correlate ERB and PBC in regard to thermal conditions.

Additional follow-up regarding survey responses:

In order to better understand the survey responses, a follow-up interview was conducted with the building officials at CSU Powerhouse. Through the interview, a deeper understanding of the HVAC system and the intentions behind various design features was gained. Using the design plans and drawings of CSU Powerhouse, the features of the HVAC system functionally being used was critically analysed. Based on the drawings of the building's HVAC system are divided between 4 and 7 zones separately in each floor with a thermostat provided for each zone. Given the layout of the building, this provides close to no control to the building occupants over the thermostat. Despite the results shown in Table (4.4), where in response to (Q 34_6), nine respondents out of 37 (24 % of the total survey respondents) selected 'Strongly Agree' in response to altering the thermostat to suit their comfort needs. One potential explanation for this discrepancy is that these nine individuals could include the facility managers of the building, who do, indeed, maintain and have control over the function of the building.

In this survey, almost all questions required a response before respondents could move to the next. This means that respondents could not skip questions that may not apply to them. A positive part of the forced response feature in a survey construct is that it is more common to receive complete survey responses but, on the other hand, it also raises the possibility of respondents randomly selecting answers to a question just to be able to finish the survey. For instance, this pattern can be noticed in (Q 59) "When leaving the windows open in the office how often do you adjust the thermostat settings to use less heating/cooling?" The option "Never" received around 89% (n=33) responses. "Never" was also the first option a survey respondent was presented with, so respondents could quickly check this option in order to get ahead in the survey. Since this response rate cannot be supported with external factors, the validity of the underlying interpretation of the responses is questionable. In order to overcome this challenge, a separate question regarding the occupant's job title would help support the responses received. Additional context to the responses received such as the differentiation between facility managers who might have control over the thermostat and regular employees who might not have control can be deciphered.

Based on the data provided in Tables 4.2 and 4.3, a large response rate was received for (Q 61_1), which states that, when a building occupant feels chilly in the office, they wear a thicker layer of clothing. The majority of respondents 97% (n=37) agree to frequently wearing a thicker layer of clothing as the response to chilly conditions. Based on the responses presented above, this high response rate can be at least partly explained through the lack of control over the thermostat experienced by building occupants.

According to the adaptive principle, "if a change occurs such as to produce discomfort, people react in ways which tend to restore their comfort" (Humphreys et al., 2002). From Table 4.3, it can be seen that a large number of respondents were inclined to (Q 62_1) open windows, (Q 62_2) wear a lighter layer of clothing or (Q 62_4) drink a cold beverage when experiencing warm conditions in the workplace. In contrast, the number of responses either agreeing or strongly agreeing (Q 62_3) to turn down the thermostat was only four. These results are understandable after communicating with the Powerhouse managers and learning that occupants do not have control over the thermostat. Hence, the occupants must take other measures to regain their comfort such as either drinking a cold/hot drink or wearing a lighter/heavier layer of clothing. The same argument can be made for the pattern seen in the responses given in Table (4.2) regarding chilly conditions.

Due to the lack of control over the thermostat based on the building design, the correlation between PBC and ERB concerning thermal conditions cannot be adequately studied using the survey responses received. Still, ERB can be assessed even without control over the thermostat. According to Mobley, Vagias, & DeWard (2009), questions in Tables (4.2) and (4.3) can indeed qualify as valid measures to determine ERB. However, PBC, on the other hand, involves beliefs that a building occupant experiences actual control and the opportunity to perform a behavior successfully (Ajzen and Madden 1986, Ajzen 1991, Conner and Armitage 1998). Since the Powerhouse building occupants experience no control over the thermostat, the perception of control a building occupant experiences over the thermal conditions in his or her workspace cannot be accurately measured.

Workspace and building design features:

To gain a deeper understanding of the building occupant's perceptions about their workspace and the building, additional open-ended questions were included as part of the survey. Tables (4.6) and 4.7 provide context to the responses by identifying the type of workspace the building occupants work in along with the privacy of their workspaces. Slightly less than half 47.5 % (n=19) of the building occupants have personal workspaces and roughly, half of the respondent population has a shared office space Table (4.6).

Table 4.6. Number of occupants in one's workspace

Do you share your primary workspace with others?	*N*	*%*
No, normally occupied by you alone	19	47.5%
Yes, shared with 1 other	2	5%
Yes, shared with 2-4 others	7	17.5%
Yes, shared with 5-8 others	3	7.5%
Yes, shared with more than 8 others	7	17.5%

Table 4.7. Type of workspace

Which of the following best describes your workspace?	N	%
Enclosed office, private	11	27.5%
Enclosed office shared with other people	2	5.0%
Cubicles with high partitions (about five feet or more)	3	7.5%
Cubicles with low partitions (lower than five feet)	3	7.5%
Workspace is open office with no partitions (just desks)	17	42.5%

Eleven respondents (27.5%) have a private enclosed office space Table (4.7). This is interesting since 47.5% of the building occupants reported earlier from Table (4.6) that they occupy their workspaces alone. To show the possible confusion between what is considered private and open workspaces, Figure 4.1 shows an example of a private office space and Figure 4.1 shows an example of open workspaces at the CSU Powerhouse.

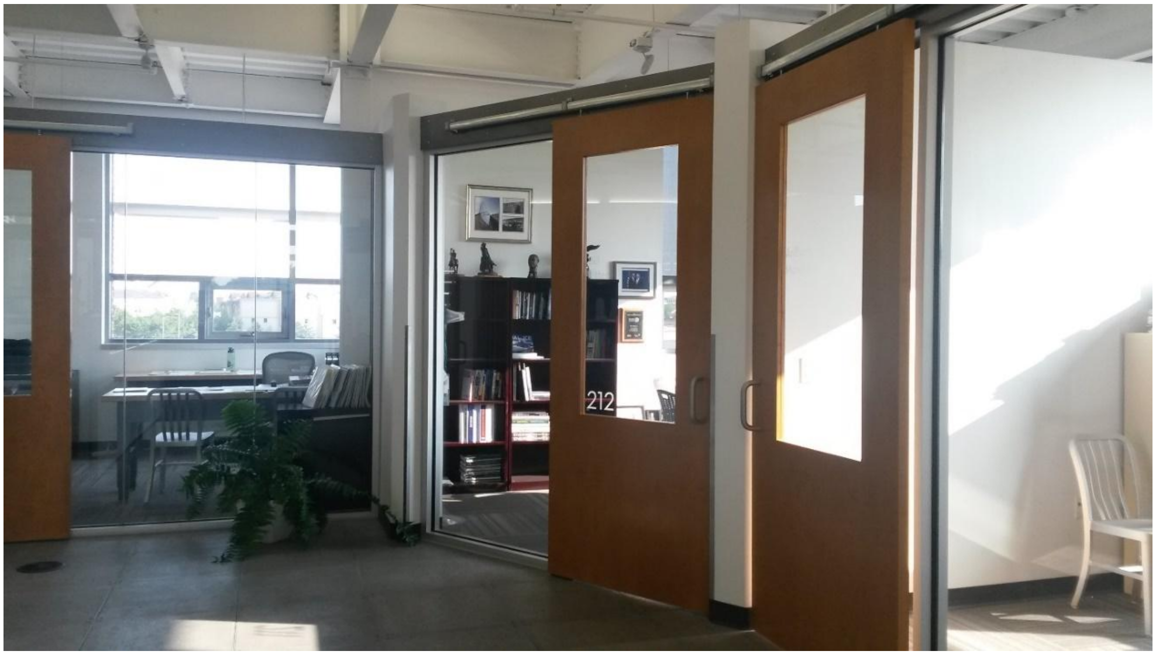


Figure 4.1. Private workspace in CSU Powerhouse

The respondents expressed discomfort and showed a lack of approval about their open workspace environment, specifically noting poor acoustic features that caused distraction from their work. Based on the responses received and a visit to the building by the researcher, the conclusion was drawn that the design of open office spaces correlates well with participants' responses. For example, some participants noted discomfort that resulted from the building features and workspace such as the acoustics in the building. For this reason, cubicles (Figure 4.2) tended to be preferred to desks set up in the open workspaces (Figure 4.3). Furthermore, some building occupants expressed that they did not have closed personal working spaces and said that the partition walls are only half of the wall height, which does not provide the necessary level of quiet they prefer. Figure 4.2 is a photograph that shows an example of shared workspaces at CSU Powerhouse.

Figure 4.2. Partly enclosed workspaces in CSU Powerhouse

Discomfort can often arise from the inability to improve one's environment when an individual feels that he or she lacks the ability to alleviate his or her comfort level. Some sources of discomfort expressed by building occupants included a high noise level and uncomfortable acoustics because of the number of open research spaces. Figure 4.3 shows an example of open workspaces seen at CSU Powerhouse.

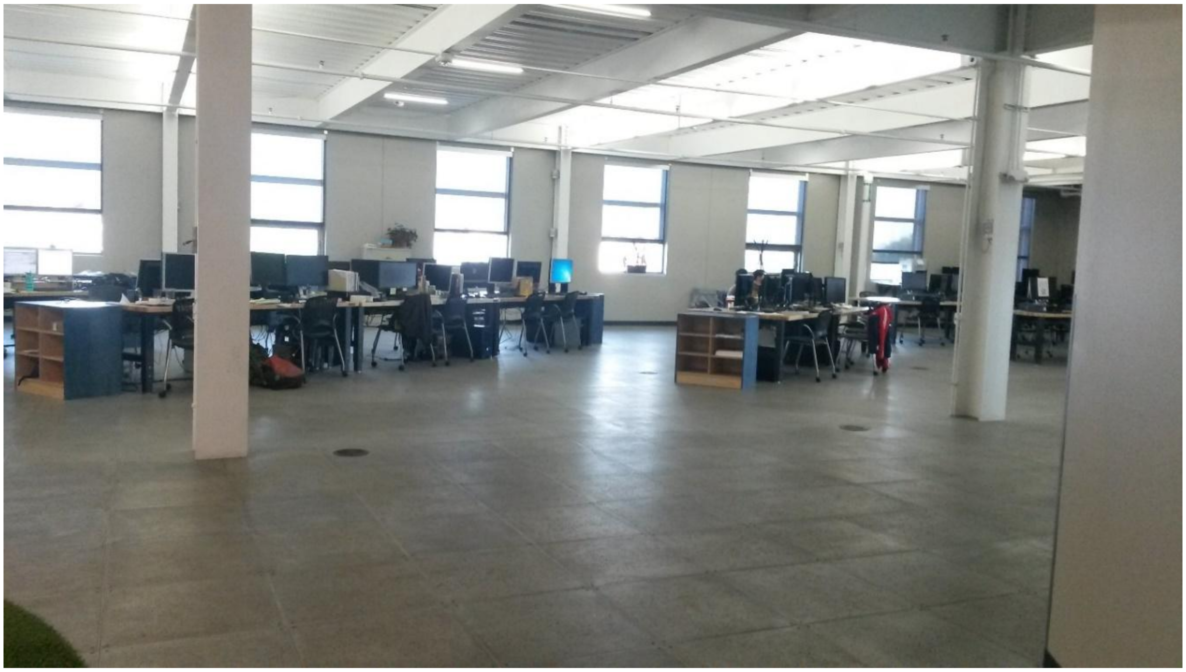


Figure 4.3. Open workspace in CSU Powerhouse

As per the previous discussion, there were two open-ended questions, which were presented to the survey respondents asking for opinions regarding design changes both in the building and in personal workspace. It is a common issue that energy efficient buildings are more focused on energy efficient features that other spheres of importance that directly affect the building occupant's comfort level might be overlooked such as personal comfort. The elaborate responses are attached in Appendix C: Survey Results-Building Features Section.

Context analysis was chosen as the method of analysis for the open-ended questions. This research method looks at the contextual meaning of the text and focuses on the characteristics of language used as communication (Hsieh & Shannon, 2005). The text data could be verbal, print, interviews, focus groups, open-ended survey questions, books and manuals (Imanari, Omori, & Bogaki, 1999; Kondracki, Wellman, & Amundson, 2002). This content analysis was completed with the goal of attaining a higher understanding of the reason behind the discomfort experienced by building occupants. The process followed in this study involves the categorization of the responses to the open-ended questions (See Appendix C) into sub-groups titled 'Temperature and Light Needs' and 'Open Floor Plans and Acoustics'. These categories were formed based on the high rate of repetitive occurrence of the above factors in the responses received for the open-ended questions. Once the responses were categorized based on change in features, reasons behind the specific discomfort with the building design were analyzed.

The following bullet points represent open-ended responses regarding temperature and light in the building and workspace:

- I find the HVAC system severely lacking. The open workspace is typically in the 70-80 range during the summer with 30-60% humidity. My lab space is never below 75 F, which is not comfortable at all. The [HVAC] system was undersized or is being poorly utilized.
- Heating /cooling. Not enough windows that open in the entire building (4th floor), no control over heating or cooling in individual offices.
- Give me more control over to temperature and light conditions in my workspace.
- The heating and cooling systems do not work sufficiently to keep the space comfortable more soundproofing/warmer flooring.
- Automatic lighting system turns off spontaneously when in room. Very annoying. Can't dim the lights. Bright enough for surgery.
- Even though the lights are automatic, I'd place the light controls nearer to the points of exit.
- There are several hours every morning when any student with their back to the south windows cannot see their monitors. Ambient light is great but one needs to see.

Another category of open-ended responses addressed acoustics and office design in the building and workspace. Below is the list of responses:

- Reduce noise
- Acoustics could be drastically improved
- Closed space for desk. Or at least cubical.
- Inefficient use of space in terms of occupants per square footage. Also, noise is a problem.
- Acoustics. Way to noisy
- Sound management
- Walls to ceiling; acoustics
- Less open desks, needs more partitions between work areas to reduce distractions
- Stairs on south side of old lab would be open. Better acoustics
- Eliminate the open floor plan
- More soundproofing/warmer flooring
- Some sort of partition for privacy in open office scheme
- I would like to see enclosed work spaces created. I avoid working in the building because the open workspace design is distracting and makes it hard to focus
- Close the gaps from the 1st floor to the second to reduce noise from the work space
- Having more privacy is better. 2nd floor is just good for interaction with other people, not for studying and doing research on your own
- Add walls. Open office floor plans are terrible!
- It is very loud in the open office space
- Better acoustics

- Acoustics are terrible. Put in carpeting down for high traffic areas and sound proofing/roofs for offices. Office etiquette around speaker phone calls and loud talking in common areas would be helpful
- More sound reduction
- Open-concept work areas do not work
- I would like my work space to be better enclosed and separated from others' work spaces
- Walls to ceiling; acoustics
- More walls. Less open space
- More walls for quiet and fewer distractions
- Dividers and noise reduction

The results from the qualitative analysis were compared to the responses received for (Q 34_4). By closely examining the responses to the open-ended questions, a major challenge is identified as the acoustics of the building. The CSU Powerhouse was designed to utilize an open workspace /floor design. The intent of this design, like most open space office designs, was to encourage collaboration between building occupants. The building is predominantly used for academics, research and research workspaces. By doing a walk-through inside the building, features in the building design that might affect the acoustics in the building design were studied. The building followed open space office design where private offices were located bordering the floor space. These private offices have partition walls that do not touch the ceiling, leaving a gap between the ceiling and partition wall, impeding better acoustics in the building.

As far as temperature control is concerned, the thermostat standard setting in the building is set close to 72 degrees Fahrenheit throughout the year and the “real feel” temperature varies between 73 and 69 degrees Fahrenheit during the summer. This information was gathered through the interview with the building managers of CSU Powerhouse. In the winter, the building occupants feel temperatures usually between 71 and 77 degrees Fahrenheit. Upon examining the responses received for “I dislike the lack of control of heat and light proximity” (Q34_4), Table (4.5), it can be seen that 51% (n= 19) respondents agree, 37% (n=10) respondents disagree to the dislike of heat and light proximity. Based on this, it appears that individuals suffer without much control over their environment. This lack of control in respect to light and heat proximity has been acknowledged by the occupants.

The intention behind the choice of HVAC system in CSU Power house was studied and it was seen that energy efficiency was an important goal as the building was successfully LEED Platinum certified. An important pursuit in the building design was identified as energy efficiency and the Radiant ceiling panels were an easy choice as Radiant ceiling panels also known as In-slab radiant heating/cooling panels are believed to create a more superior thermal environment than conventional systems and are considerably more energy efficient (Imanari, Omori, & Bogaki, 1999). With the Powerhouse, Energy Institute’s goal to reach LEED platinum certification the in-slab radiant heating seems to be an easy, feasible choice. Generally, radiant heating /cooling systems have several potential advantages such as improved thermal comfort, indoor air quality (IAQ) and energy efficiency with reduced life cycle costs (Raftery et al., 2012). The Powerhouse has In-slab heating/cooling system installed in the ceiling, unlike some buildings that have pipes installed in the ceiling and the floor. The In-slab heating is present only in the ceiling, resulting in cold floors according to the responses in open-ended questions. The In-slab heating/cooling system faces downward from the ceiling and this distance between the floor and the ceiling on occasion results in cold floors. In many instances, the type and design of the HVAC systems could simultaneously affect various other categories of comfort such as acoustics, privacy, and floor plan design. Based on the responses received from the open-ended questions, it appears that many building occupants also experience high levels of discomfort in regard to acoustics. The in-slab radiant heating system restricts better acoustics as the false-ceiling could interfere with the functional ability of the in-slab heating system. The lack of false-ceiling drop is a definite contributor to poor acoustical performance of the building. If this issue had been identified early on in the design phase of the project, more sound absorbing material could have been included in the design along with full height partition walls.

Based on the responses received it is clear that the building occupants experience no control over the thermostat. Therefore, in order to successfully study the correlation between ERB and PBC in regard to thermal condition using a building such as the CSU Powerhouse where there is not any control provided to the building occupants. Some steps that can be taken to identify the best building to conduct this study would include doing a walkthrough of the building prior to developing a customized survey instrument by investigating the HVAC system design along with its functionality, thermostat location and numbers.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The initial goal of this study was to investigate the correlation between Environmentally Responsible Behavior (ERB) and Perceived Behavior Control (PBC) concerning thermal conditions in high-performing buildings. As the study progressed, it was found that the building chosen in which to conduct the research, CSU Powerhouse, does not allow its building occupants any control over the thermostat. Although the initial research goal could not be achieved through this study, by conducting follow-up content analysis, the impact of various building design features on the comfort level of building occupants was still able to be investigated.

From the content analysis, it is evident that some of the building occupants experience a lack of comfort in their workspace and building because of various design features and functions such as open floor design, low partition walls, and the lack of control over heating system.

Addressing Research Question

The research question of this study was "Does the PBC in regard to thermal conditions experienced by building occupants improve the rate of ERB exhibited by building occupants?" Based on the literature review, it was postulated that improved PBC concerning thermal conditions would increase the rate of ERB exhibited by the building occupants (Ajzen et al., 1986; Ajzen, 1991). In order to adequately study the correlation between PBC and ERB, it is necessary to identify a population in which the building occupants have freedom to alter the thermostat to suit their comfort needs. This is of key importance since PBC theory is based on the assumption that building occupants can experience actual control first hand (Ajzen, 1991). A content analysis was conducted to learn about the compatibility and functionality of building design features since the quantitative analysis was not possible to perform as indicated in Chapter IV.

The result of the content analysis of the open-ended questions indicated that key design features included in the building to increase energy efficiency had unintended impacts on the comfort of building occupants, either directly or indirectly. Based on the responses received 68 percentage of the total responses received, the respondents identified experiencing either poor acoustics, poor lighting and/or poor thermal comfort in the building. The current acoustics conditions of the building are affected by factors such as the open floor plan along with the radiant in-slab heating/cooling design features combined with the number of hard surfaces present in the building (Quinn-Vawter, 2016).

Each design feature chosen in the building influences the other. For example, the open floor plan was chosen to improve collaboration between co-workers and facilitate complete day lighting within the building. In addition, the private offices located along the border of the building have partition walls that do not reach the ceiling, leaving a gap between the partition wall and the ceiling to facilitate the flow of day lighting into the centrally located cubicles. Although the above stated features work well with each other to achieve their intended goals, these design features had unintended impacts on the acoustic conditions in the building.

Through this qualitative analysis, it shows that the design features do not necessarily support each other's functionality in maximizing the comfort level of building occupants. Most often, building occupants experience lack of comfort and productivity as the price to be paid for high-energy efficiency. Prioritizing building occupant comfort and productivity along with the energy efficiency of buildings might be the place to start to reach higher levels of functional occupant comfort. This comfort levels could be attained by involving the future building occupants in the design phase of the project. For example, if the issues regarding challenging acoustical conditions at the CSU Powerhouse had been predicted earlier in the design or construction phase of the project, affordable and timely measures could have been taken to minimize the number of hard surfaces in the building.

Limitations to the study

The sample size received as response for open-ended questions included only 26 out of the 50 percentage received for the survey from building occupants. Receiving a higher response rate for the open-ended responses and the survey itself would have improved the reliability of the responses received. The study might also be strengthened by interviewing building occupants: (1) to gain a deeper understanding of how their comfort needs are impacted by the building design features and (2) to better understand their actual work space within the building. Further, conducting focus interviews with building proctors and facility managers regarding common complaints received about the discomfort experienced by building occupants and the steps taken to overcome these challenges could add more context to the building occupants' responses.

Future Study Recommendations

With occupant behavior as the weakest link in energy efficiency (Picklum, Nordman, & Kresch, 1999), studying the correlation between PBC and ERB related to thermal conditions would produce results of significant value. Gaining a clear understanding of the building layout and then distributing a custom built survey to occupants of high-performing buildings could overcome some of the challenges experienced in this study. The structure of the online survey instrument could be improved by incorporating features that enable segregated responses from building occupants who have no control over the thermostat. Including a close-ended (Y/N) question with a skip, logic ("Do you have control over the thermostat in the building /workspace?") would allow a building occupant who experiences no control over the thermostat to skip the question related to the frequency the thermostat is altered. Those responses can then easily be filtered out of the sample set during analysis.

Another consideration is that the size of the sample in this study is rather small so, in order to gain the ability to claim statistical significance, the survey should be distributed to two or three other high-energy performing buildings. Comparing the responses from these different buildings would provide more perspective. Additionally, the choice of the building in which to conduct this study is of high importance. A walk through in a building prior to the study would provide an understanding of the HVAC design along with the provision of control over building occupants thermal surrounding. Choosing a building that provides control to the building occupants over the thermostat is a prerequisite to adequately determine the correlation between PBC and ERB.

Since high-performing buildings can be complicated, involving the building occupants during the design phase of the project would offer a greater possibility of reaching a higher functional comfort rate. Designing and constructing highly energy efficient buildings that provide a comfortable and productive work environment for their building occupants is crucial and addresses a research gap of comfort of building occupants versus energy efficiency of the building. Achieving both of these targets simultaneously rather than sacrificing one for the other is a challenging goal, but one that can be overcome.

Significance of the Study

Since people spend 90% of their time indoors, trying to work with high levels of discomfort in their work environment can produce constant psychological stress that results in decreased productivity and increases in health issues (Humphreys et al., 2004). This is especially true in relation to green buildings as it is common to have green buildings that are more fragile in their performance and would require that all aspects work well together (Leaman & Bordass, 2007). In many instances, the occupants of the building are excluded in the design phase; the donors with organization officials are more likely involved. If the building occupants are involved during the design phase of the project, their basic comfort (thermal, lighting, noise) and productivity needs can be easily met during that early interaction. More importantly, the functional needs of building occupants might not be known until one's space is being used, as they might not have knowledge of their functional comfort needs prior to occupying one's workspace. This study has shown that the high performing design features tend to produce discomfort to building occupants in the facility used as a case study. This additionally verifies that further studies need to be conducted to further understand and help improve the comfort level of building occupants in high performing buildings.

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APPENDIX A

IRB RESEARCH INTEGRITY & COMPLIANCE REVIEW OFFICE'S INSTITUTIONAL REVIEW BOARD EXEMPTION FORM

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To: Rodolfo Valdes Vasques, Ph.D. Construction Management Swaetha Jebackumar, Construction Management
From: IRB Coordinator, Research Integrity & Compliance Review Office (RICRO_IRB@mail.colostate.edu)
Re: Understanding the Correlation Between Energy Conservation Behavior Intention of Building Occupants and their Beliefs about Climate Change and Workspace Ownership
IRB ID: 095 -16H **Review Date:** November 2, 2015
This project is valid from three years from the review date.

The Institutional Review Board (IRB) Coordinator has reviewed this project and has declared the study exempt from the requirements of the human subject protections regulations with conditions as described above and as described in 45 CFR 46.101(b):

Category 2 - Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

The IRB determination of exemption means that:

This project is valid for three years from the initial review. After the three years, the file will be closed and no further research should be conducted. If the research needs to continue, please let the IRB Coordinator know before the end of the three years. You do not need to submit an application for annual continuing review.

You must carry out the research as proposed in the Exempt application, including obtaining and documenting (signed) informed consent if stated in your application or if required by the IRB.

Any modification of this research should be submitted to the IRB through an email to the IRB Coordinator, prior to implementing any changes, to determine if the project still meets the Federal criteria for exemption.

Please notify the IRB Coordinator (RICRO_IRB@mail.colostate.edu) if any problems or complaints of the research occur.

Please note that you must submit all research involving human participants for review by the IRB. **Only the IRB or designee may make the determination of exemption**, even if you conduct a similar study in the future.

APPENDIX B

SURVEY INSTRUMENT

Understanding the correlation between Energy Conservation Behavior Intention of Building Occupants and their Beliefs about Climate Change and Workspace Ownership.

Dear Participant,

My name is Swaetha Jebackumar. I am a graduate student in the Department of Construction Management at Colorado State University. I am requesting your assistance with a survey to investigate the perception of building occupants towards energy conservation in their workspace. The Principal Investigator for this study is Dr. Rodolfo Valdes-Vasquez from the CM Department at CSU, and I am the Co-PI.

We would like you to take an anonymous online survey. Participation will take approximately between 10 to 15 minutes to complete. Your participation in this research is voluntary. If you decide to participate in the study you may withdraw your consent and stop participation at any time without penalty. We will not collect your name or personal identifiers. When we report and share the data we will combine the data from all participants. While there are no direct benefits to you, we hope to gain more knowledge on the perception of building occupants towards energy conservation in their workspace.

There are no known risks in participating in this study. It is not possible to identify all potential risks in research procedures, but the researchers have taken reasonable safeguards to minimize any known and potential, but unknown, risks. To indicate your consent to participate in this research and to continue on to the survey, please click here: <survey link>.

At the end of the survey you will have an opportunity to enter a drawing to win one of two gift cards for CSU Bookstore, valued at $25 each. Participation in this drawing will require you to provide an email address, which will not be connected in any way to your responses on this survey. Participants will be selected at random and notified using the email addresses they provide. All email addresses will be destroyed once the random drawing process has concluded and winners have been notified.

If you have any questions about the research, please contact Swaetha Jebackumar or Dr. Rodolfo Valdes-Vasquez. If you have any questions about your rights as a volunteer in this research, contact the CSU IRB.

We appreciate your participation and help!

Best Regards,

Swaetha Jebackumar, LEED GA, Graduate Research Assistant

SECTION I - DEMOGRAPHICS

How many years have you worked in this building?

- Less than 1 year
- 1-2 years
- 3-5 years
- More than 5 years

How long have you been working in your present working space?

- Less than 3 months
- 7-12 months
- 1-2 years
- More than 2 years

In a typical week, how many hours do you spend in your workspace?

- 10 or less
- 11-20
- 21-30
- 31-40
- More than 40

What is your age?

- 18-24
- 24-34
- 34-44
- 45-54
- Over 55
- Not willing to share

What is your gender?

- Female
- Male
- Prefer not to respond

SECTION II - ENVIRONMENTALLY RESPONSIBLE BEHAVIOR (ERB)

Questions	Never	Rarel y	Sometim es	Most of the time	Alway s	No control over thermostat
When leaving the office in the winter, how often do you adjust thermostat settings to decrease your room temperature?						
When leaving the office in the summer how often do you adjust the thermostat settings to increase?						
When you open the windows in the office how often do you adjust the thermostat settings to use less heating/cooling?						

When the office is chilly/cold what do you do? (Select all that apply)

	Strongly Agree	Agree	Disagree	Strongly Disagree
Wear thicker layers of clothing				
Using a space heater				
Turn up the heat up by adjusting the thermostat				

Drink a hot beverage				
Wear layers				

When your office is too warm/hot, what do you do? (Select all that apply)

	Strongly Agree	Agree	Disagree	Strongly Disagree
Open the windows				
Wear a lighter layer of clothing				
Use an electric fan				
Drink a cold beverage				
Turn down the thermostat				

SECTION III - PERCEIVED BEHAVIORAL CONTROL (PBC) REGARDING THERMAL CONDITIONS:

If Yes, please answer the following questions

Questions	Never	Rarel y	Sometim es	Most of the time	Alway s	No control over thermostat
I always control the temperature at my workspace to meet my needs.						
I dislike the lack of control of heat and light in my immediate proximity.						
I often alter the main						

thermostat conditions in my office space in order to suit my comfort needs.						

SECTION III-WORKSPACE AND BUILDING DESIGN FEATURES:

Which of the following best describes your workspace?
- ○ Enclosed office, private
- ○ Enclosed office shared with other people
- ○ Cubicles with high partitions (about 5 or more feet high)
- ○ Cubicles with low partitions (lower than five feet high)
- ○ Workspace in open office with no partitions(just desks)
- ○ Other _______________________________

Do you share your primary workspace with others (Select all that apply)
- ○ No, Normally occupied by you alone
- ○ Yes, Shared with 1 other
- ○ Yes, Shared with 2-4 others
- ○ Yes, Shared with 5-8 others
- ○ Yes, Shared with more than 8 others

Is there any design feature that you would change about the building overall?

- ○ Yes
- ○ No

If yes, what? _____________________

Is there any design feature that you would change about your workspace overall?

- ○ Yes
- ○ No

If yes, what? _____________________

Thanks for your participation!

APPENDIX C

SURVEY RESULTS -BUILDING FEATURES SECTION

Is there any design feature that you would change about your workspace overall?

Reduce noise
Acoustics could be drastically improved
Heating/cooling. Not enough windows that open in the entire building (4th floor), no control over heating or cooling in individual offices.
Closed space for desk. Or at least cubical.
Stairs in different Places
Inefficient use of space in terms of occupants per square footage. Also, noise is a problem.
Get rid of high-water lawn and put in additional parking.
Acoustics. Way to noisy.
I would rework the automatic door opener on the front door to not activate whenever the door is opened, but only when the button is pressed.
sound management
We would have cubicles rather than open spaces with desks.
walls to ceiling; acoustics
Less open desks, needs more partitions between work areas to reduce distractions
Stairs on south side of old lab would be open. Better acoustics.
Eliminate the open floor plan.
more soundproofing/warmer flooring
Some sort of partition for privacy in open office scheme
The heating and cooling systems do not work sufficiently to keep the space comfortable
I would like to see enclosed work spaces created. I avoid working in the building because the open work space design is distracting and makes it hard to focus.

Cubicles with desks that have drawers and sufficient work space to fit a monitor, keyboard, and have space to work. Close the gaps from the 1st floor to the second to reduce noise from the work space. Move stoves out of the new building or install proper ventilation. The smell of smoke and particulates is quite strong on the second floor when more than one fume hood is running. Add some sort of acoustic absorbing structure to ceilings/walls. Put tops on all the PI's boxes so their phone calls are private again. Move the senior design students off the second floor. Tuesdays and Thursdays are essentially 50 undergrads screaming at each other from across the room. Somewhere to park would be great. The second floor has never been cleaned in three years. Also, chairs that adjust and are functional. I would also add a second opaque shade on the south facing windows in the building. There are several hours every morning when any student with their back to the south windows cannot see their monitors. Ambient light is great but one needs to see.
Walls that go to the ceiling. Real walls instead of glass
Having more privacy is better. 2nd floor is just good for interaction with other people, not for studying and doing research on your own.
Add walls. Open office floorplans are terrible!!
It is very loud in the open office space
Better acoustics.

Q) Is there any design feature that you would change about your building overall?

Reduce noise
More electrical outlets, or better location of outlets to be useful
Acoustics are terrible. Put in carpeting down for high traffic areas and sound proofing/roofs for offices. Office etiquette around speaker phone calls and loud talking in common areas would be helpful.
Automatic lighting system turns off spontaneously when in room. Very annoying. Can't dim the lights. Bright enough for surgery.
Even though the lights are automatic, I'd place the light controls nearer to the points of exit.
walls to ceiling; acoustics

Give me more control over to temperature and light conditions in my workspace.
More sound reduction
Open-concept work areas do not work
I would like my work space to be better enclosed and separated from others' work spaces.
I find the HVAC system severely lacking. The open work space is typically in the 70-80 range during the summer with 30-60% humidity. My lab space is never below 75 F, which is not comfortable at all. The system was undersized or is being poorly utilized.
More walls. Less open space
More walls for quiet and fewer distractions.
dividers and noise reduction