

Electronic Theses and Dissertations, 2004-2019

2016

Investigating the Influence of the Built Environment on Energy-Saving Behaviors

Brittany Sellers
University of Central Florida

 Part of the [Cognitive Psychology Commons](#)
Find similar works at: <https://stars.library.ucf.edu/etd>
University of Central Florida Libraries <http://library.ucf.edu>

This Doctoral Dissertation (Open Access) is brought to you for free and open access by STARS. It has been accepted for inclusion in Electronic Theses and Dissertations, 2004-2019 by an authorized administrator of STARS. For more information, please contact STARS@ucf.edu.

STARS Citation

Sellers, Brittany, "Investigating the Influence of the Built Environment on Energy-Saving Behaviors" (2016). *Electronic Theses and Dissertations, 2004-2019*. 5280.
<https://stars.library.ucf.edu/etd/5280>

INVESTIGATING THE INFLUENCE OF THE BUILT ENVIRONMENT ON ENERGY-
SAVING BEHAVIORS

by

BRITTANY C. SELLERS

B.A. Flagler College, 2008

M.A. University of Central Florida, 2013

A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in the Department of Psychology
in the College of Sciences
at the University of Central Florida
Orlando, Florida

Fall Term
2016

Major Professor: Florian G. Jentsch

© 2016 Brittany C. Sellers

ABSTRACT

This dissertation addresses a gap in the existing sustainability behavior research, by integrating research from the social sciences about environmental attitudes and knowledge with approaches from engineering regarding the characteristics of the built environment. Specifically, this dissertation explores the role of both environmental knowledge and design features within the built environment on building occupants' energy behaviors throughout the course of an environmental conservation campaign. Data were collected from 240 dormitory residents using a multi-phase questionnaire approach to study these factors and their combined impact within the context of environmental sustainability practices on UCF's campus. The results from a series of correlational and multiple regression analyses indicate that both the design components of the built environment and the attitudes held by individuals within that environment have a significant positive influence on behaviors. Furthermore, these findings indicated that this effect increases significantly when the two factors work together. Finally, the results show that pro-environmental attitudes and behaviors can be successfully targeted through a cue-based energy conservation campaign. By addressing a gap in the extant Human Factors research about the relationship between attitudinal factors and the built environment, this dissertation provides a unique contribution to the field and points the way towards development of promising solutions for encouraging sustainable behaviors.

ACKNOWLEDGMENTS

I would like to express my sincere appreciation to the many individuals who have helped to make this dissertation possible.

I am very grateful to Dr. Stephen Fiore for his mentorship, enthusiasm, and guidance throughout the development of this line of research and serving on my committee. I would also like to thank Dr. Florian Jentsch for serving as my advisor and committee chair, providing a solid foundation for my graduate studies and beyond, and supporting me in my pursuit of this burgeoning area of research. In addition, a thank you to my committee members, Dr. Valerie Sims and Dr. Janan Smither for their valuable insight and direction.

Next, I would like to express my appreciation for the opportunity to conduct this research at UCF's Office of Sustainability, for which Alexandra Kennedy and Dustin Jackson advocated and made possible. I would also like to thank Jacob Bonne and the Housing Sustainability Committee whose direction and input shaped this work.

Finally, I thank my family, boyfriend, and many cherished friends for their unwavering love, encouragement, understanding, and practical support throughout this entire process, especially during the particularly challenging last year of this dissertation. I love you and would not have been able to accomplish this without you.

TABLE OF CONTENTS

LIST OF FIGURES	xiii
LIST OF TABLES	xiv
CHAPTER ONE: INTRODUCTION.....	1
Problem Statement	1
How to Understand Pro-Environmental Behaviors	2
Sustainability Research Context	4
Research Purpose and Contribution.....	6
CHAPTER TWO: LITERATURE REVIEW	8
Conceptual Overview.....	8
Environmental Attitudes	9
Origins of Environmental Attitudes.....	9
Elements of Environmental Attitudes and Other Related Influences	10
Environmental Attitudes in PEB Models.....	12
Knowledge as a Central Tenet of PEB	14
General vs. Behavior-Specific Knowledge.....	15
Declarative vs. Subjective Knowledge	16
Knowledge Development as an Iterative and Dynamic Process	17

Environmental Campaigns.....	17
Source of Message	18
Effectiveness and Awareness of Campaign Information.....	19
Cueing Pre-Existing Knowledge.....	20
Summary of Environmental Attitude and Campaign Research	22
The Built Environment	22
Procedural Knowledge.....	23
Training and Adaptability	24
The Influence of Declarative and Subjective Knowledge on Interactions Within the Built Environment.....	26
Comfort.....	27
Two Approaches to Comfort	27
Ease of Use	29
Control	30
Types of Control Across Devices	31
Summary of Built Environment Research	33
Summary of Conceptual Overview.....	33
Contextual Overview	34

Green Buildings and Related Programs	35
Design and Amenities	37
Sustainability Initiatives on Campuses and at UCF.....	38
Energy-Saving Competitions on University Campuses.....	39
Kill-A-Watt Competition	40
Integrating Concepts and Context.....	41
Initial Knowledge, Comfort, and Control	42
Available Amenity	42
Kill-A-Watt Behaviors.....	43
User Knowledge Regarding How to Use the Amenity.....	44
Information Seeking Behaviors	45
User Perception of Ease of Use with Device	45
User Knowledge and Ease of Use.....	46
User Perception of Ability to Control Device.....	46
User Knowledge and Control.....	47
User Ease of Use and Control.....	47
Understanding Regarding the Importance of Climate Change	48
Combined Influence of Built Environment and Environmental Attitudes	50

Campaign Influence	50
Campaign Awareness.....	50
Participation in Kill-A-Watt Competition	51
CHAPTER THREE: METHOD AND MATERIALS.....	52
Study Development.....	52
Participants.....	53
Procedure	55
Surveys.....	57
February Surveys (see Appendix A).....	57
Biodata	57
Amenities Within the Built Environment	57
Kill-A-Watt Behaviors.....	58
Perception of Knowledge, Ease of Use, and Control with Amenities within the Built Environment.....	58
Knowledge Regarding How to Use Amenities within the Built Environment.....	59
Awareness of Kill-A-Watt	59
Participation in Kill-A-Watt	59
Seeking Out Knowledge	59

Understanding Regarding the Importance of Climate Change	60
April Surveys (see Appendix B)	60
Awareness of Kill-A-Watt	60
Participation in Kill-A-Watt	61
Seeking Out Knowledge	61
CHAPTER FOUR: RESULTS	62
Data Screening	62
Duplicate Participation.....	62
Participant Attrition	64
Attrition at the Consent Stage.....	64
Attrition During T1	64
Completion of T1	65
Attrition between T1 and T2.....	65
Completion of T2.....	65
Analyses for Selective Attrition.....	67
Off-Campus Participation	67
Duration of Participation.....	68
Participant Demographics	69

Analyses	71
Scores Reported Across Measurement Scales	71
Individual Item Scores	71
Aggregate Scores	71
Average Scores	72
Internal Consistency.....	72
Understanding Regarding the Importance of Climate Change	72
Knowledge Regarding How to Use Amenities	73
Hypothesis Testing.....	73
Built Environment.....	74
Amenities on Behaviors	75
User Knowledge.....	78
Seeking Out Information.....	79
User Ease of Use	80
User Knowledge and Ease of Use.....	81
User Control.....	81
User Knowledge and Control.....	82
User Ease of Use and Control.....	82

Environmental Attitudes	83
Combined Influence of the Built Environment and Environmental Attitudes	84
Campaign Awareness.....	86
CHAPTER FIVE: DISCUSSION.....	88
Study Findings	88
The Built Environment	88
Environmental Attitudes	94
Combined Influence of Built Environment Factors and Environmental Attitudes.....	96
Awareness of Kill-A-Watt Competition	97
Limitations and Future Research	98
Demographic Factors	98
Methodological Considerations	100
Measurement Considerations.....	101
Limitations Regarding Focus and Scope	103
Conclusion	106
APPENDIX A: FEBRUARY SURVEYS	109
APPENDIX B: APRIL SURVEYS	130
APPENDIX C: IRB APPROVAL LETTER	148

LIST OF REFERENCES 150

LIST OF FIGURES

Figure 1: Participant attrition	66
---------------------------------------	----

LIST OF TABLES

Table 1 Housing Community Representation and Participation Rate in Current Study.....	70
Table 2 Descriptive Statistics for Each Variable Reported at T1 and Kill-A-Watt Behaviors Reported at T2.....	76
Table 3 Bivariate Correlations Across Each Variable Reported at T1 and Kill-A-Watt Behaviors Reported at T2.....	77
Table 4 Single Regression for the Individual Influence of Each Variable at T1 on Reported Kill- A-Watt Behaviors Reported at T2	78
Table 5 Forward Regression Results for the Combined Influence of Built Environment and Attitudinal Factors at T1 and Reported Kill-A-Watt Behaviors Reported at T2.....	86

CHAPTER ONE: INTRODUCTION

Problem Statement

With climate change threatening the very existence of our species, it is imperative that the scientific community collaborates to provide research-based strategies and solutions to combat environmental problems. At present, a variety of research efforts in the fields of engineering and social sciences have provided significant contributions to this area (Hua, Oswald, & Yang, 2011; Katzeff et al., 2013; Li, et al., 2014). However, Human Factors/Ergonomics (HF/E), as a discipline focused on designing for the human, needs to also advance in this area and make the impact of climate change on human performance a key concern of the field (Hanson, 2013; Fiore, Phillips, & Sellers, 2014). To begin, the concept of sustainability is quite central to the field; when designing for sustainability, and thus for the preservation of our species, we are, indeed, designing with the human in mind (Phillips, Sellers, & Fiore, 2010; Thatcher, 2013). Additionally, with our specialized knowledge and expertise regarding human capabilities and limitations with systems, researchers within the HF/E community have a unique opportunity to contribute to this area. Specifically, by exploring solutions that are sustainable and do not sacrifice human comfort, we can re-shaping traditional notions of sustainability, conservation, and living “green” (Fiore, Phillips, & Sellers, 2014; Paz, Sellers, Fiore, & Richards, 2012; Thatcher, 2013; Zink & Fischer, 2013).

Whether occupants are being confronted with a new, energy-saving feature in a green-certified building, or are being challenged to change their behaviors within a familiar, non-green environment, there are several considerations that play a role in determining long-term adoption

of these behaviors: User knowledge and attitudes towards why it's important to both take action (Lee, 2010), an understanding regarding how to utilize the feature and/or engage in the behavior (Tuomey, 2009), user comfort (Brown, Dowlatabadi, & Cole, 2009), and a sense of control (Hua, Oswald, & Yang, 2011). In regard to the first component regarding user knowledge, consideration of concepts provided from extensive research across other branches of the social sciences, such as environmental, cognitive, and social psychology can provide important insight regarding how best to empower users with the relevant information regarding why a behavior is important and the desire to engage in this behavior (Alahmad, Nader, Cho, Shi & Neal, 2011; Bowler, Buyung-Ali, Knight, & Pullin, 2010; Corbett & Muthulingam, 2007; Janda, 2011; Sellers, Fiore, & Szalma, 2013)

To address the other, less-studied, but promising factors regarding the built environment, from an HF/E perspective, a user-centered design can supplement existing engineering approaches to ensure that sustainable features are easy to understand, use, and control (Kuijjer & de Jong, 2009; Paz, Sellers, Fiore, & Richards, 2012; Thatcher, 2013; Wever, van Kuijk, & Boks, 2008). Furthermore, by considering both the attitudinal and built environment factors, HF/E researchers may gain better insight and more robust understanding regarding how to best influence pro-environmental behaviors.

How to Understand Pro-Environmental Behaviors

The first component (i.e., user knowledge) includes one's level of understanding why these behaviors are important for battling climate change. Research has demonstrated that when users understand why it's important to engage pro-environmental behaviors (PEB) they are much

more likely to support, and potentially engage in, the design features within the built environment and the behavioral impact sought through their implementation (Deuble & de Dear, 2012). In fact, users often demonstrate a “forgiveness factor” in their reported feelings of satisfaction towards the design of green buildings and amenities once they are aware of the positive environmental impact of their actions (Brager, Paliaga, & de Dear, 2004).

In terms of the next component (understanding regarding how to use a device), research has demonstrated that providing education regarding new green features is crucial for their adoption by the users (Alahmad, Nader, Cho, Shi & Neal, 2011; Brown & Cole, 2008; 2009; Tuomey, 2009). A certain level of competency is required in order to use a new device or best utilize a familiar device in a more sustainable manner, so at least a basic introduction to these amenities should always be provided. With a basic understanding of how to utilize the relevant features, the process of using a green device can become easier and even more comfortable to use (Deuble & de Dear, 2012).

In regard to user comfort, the HF/E community has the capability to provide a variety of solutions towards improving user satisfaction while promoting environmental sustainability (Paz, Sellers, Fiore, & Richards, 2012; Thatcher, 2013). These solutions span the design of the larger built environment, such as a housing community, all the way down to individual features, such as lighting fixtures and thermostats (Hedge & Dorsey, 2013; Sellers & Fiore, 2013). With the knowledge regarding both how users interact with these designs, as well as the user’s level of satisfaction with these interactions, we are more likely to improve comfort and encourage PEB (Brown & Cole, 2009; Kuijer & de Jong, 2009).

Finally, it's important to consider the role of user control in order to maximize the likelihood that these long-term PEB are followed (Weir, 2013). Simply put: if an amenity within a building allows for a certain extent of control, and a building user understands how to properly use and control the device, he or she will be more likely to utilize it (Mallawaarachchi, De Silva, & Rameezden, 2013). This level of understanding, and subsequently control, moves the role of the user from a passive to an active inhabitant and is also likely to increase their perceived level of comfort and subsequent participation in relevant PEB (Cole, 2010).

Climate change is both a critically important and overwhelming daunting problem to solve due to both its' scale and severity. As such, individuals may feel powerless about their ability to tackle a problem of this magnitude (Bandura, 1982) and significance (Stokols, Misra, Runnerstrom, & Hipp, 2009; Sellers, Fiore, & Szalma, 2013) with simple behaviors alone. However, I submit that, by simultaneously taking into account the influence of environmental attitudes and knowledge regarding the significance of these behaviors together with the impact of user knowledge regarding how to carry out these pro-environmental behaviors within the built environment, as well as user comfort and control, we are better able to effectively encourage long-term PEB.

Sustainability Research Context

The current societal shift toward sustainability, and changes in both the design of the built environment and the practices afforded and encouraged therein, are also being observed in universities. In addition to reducing waste, and therefore, reducing unnecessary costs, this shift has become a necessary component toward remaining competitive. In particular, colleges are

now ranked according to their level of environmental commitment in such publications as *The Princeton Review's Guide to Green Colleges*. The University of Central Florida (UCF) is actively involved in such a transition. UCF's efforts include a Unifying Theme focused on environmental sustainability and a sustainability initiatives division, Sustainable UCF, that supervises all building construction in order to ensure that Leadership in Energy and Environmental Design (LEED) standards are met. Sustainable UCF also oversees, manages, and implements programs designed to encourage participation in PEB on campus. For example, in conjunction with Housing and Residence Life, students are encouraged to participate in the annual Kill-A-Watt competition each spring by reducing their energy use. This program has drawn involvement from all housing communities on campus and has saved tens of thousands of dollars for UCF annually. However, while students may benefit from increased satisfaction and productivity by living in dorms with sustainable practices (Lockwood, 2006), it is important that universities know why and how these changes occur (Broido & Campbell, 2008). At present, the data available regarding UCF's outreach programs includes only the number of participants and energy saved. More specifically, little is known regarding the degree to which residents understand how to conduct energy-saving behaviors, the influence of comfort and control on carrying out these behaviors, or the perceived importance of taking part in these campaigns at all. Furthermore, nothing is known about how these programs may, in turn, influence these components, or how students perceive these factors within their own particular housing community; the context in which PEBs would occur.

Research Purpose and Contribution

The purpose of this dissertation is to address this gap in involvement in sustainability research on the part of the HF/E community by integrating research from the social sciences with engineering approaches to the built environment, and exploring how these facets interrelate in terms of encouraging knowledge, comfort, and control, all within the context of environmental sustainability practices on UCF's campus. Specifically, this work investigates how attitudes, the design features within the built environment, and the combined effect of these two sets of factors influence student energy conservation. Additionally, this effort investigates the degree to which campus awareness programs influence student knowledge and control of the relevant features and potential PEB in their dormitory rooms. This research contributes to both theory and practice in HF/E. First, from the theoretical standpoint, this dissertation stretches HF/E research through a principled study of the relation between the built environment and human behaviors within that environment in the context of sustainability. Second, from the practical standpoint, this dissertation can help save energy and money, support UCF's "Unifying Theme" of environmental sustainability ("a campus-wide program designed to encourage the inclusion of environmental issues into class projects/papers/activities – regardless of subject") and its competitive reputation as both an "American College and University Presidents' Climate Commitment" signatory and through its "green college" ranking according to the Princeton Review.

The growing interdisciplinary field of environmental sustainability has drawn from a number of fields to examine the human impact on a variety of issues. This research has included a focus on attitudinal factors such as environmental attitudes and knowledge, as well as how

these orientations interact with sustainability initiatives (Milfont, 2007; Nordlund & Garvil, 2002; Steg & Vlek, 2009; Thompson & Barton, 1994). Additionally, consideration has been given to behavioral factors such as the perceived difficulty of PEBs and preference between one type of PEB and another and what it takes to persuade people to engage in environmentally appropriate ways (Green-Demers, Pelletier, & Menard 1997). Although these approaches have advanced our understanding of environmental sustainability and the psychological factors associated with it, there remain critical gaps from the HF/E perspective. At issue is the degree to which we understand how user knowledge, comfort, and control interact with the built environment. Furthermore, very little is known regarding the combined influence of both environmental attitudes (which provide a motivation or direction towards behaviors) and the design of the built environment (the devices through which these behaviors must occur). As such, this dissertation specifically focuses on both attitudes and the built environment in a field setting in order to explore these combined influences, move this body of work forward, and redress this important gap.

Together, this contribution to theory and practice, will serve as a contribution to the larger, macro goal to “identify and mobilize the psychological and situational circumstances that enable individuals to move from anxiety and passivity in the face of global threats toward constructive collaborative action” (Stokols, Misra, Runnerstrom, & Hipp, p. 182, 2009).

CHAPTER TWO: LITERATURE REVIEW

Conceptual Overview

In order to understand how to most effectively influence PEB, it is important to review a variety of work that has been conducted within the social sciences and engineering that has addressed these behaviors and the environment in which they are conducted. Specifically, the built environment has typically been studied primarily from an engineering perspective, while behavioral interventions are primarily studied from a psychological perspective. As such, I begin with a review the body of work from social psychology and environmental psychology regarding environmental attitudes. I specifically discuss the key role of declarative and subjective knowledge about the impact of behaviors in terms of influencing environmental problems and climate change, and describe the campaigns designed to influence them. Then, I move into the realm of the built environment to discuss the component of procedural knowledge, which defines one's understanding regarding how to utilize the appropriate features in order to engage in PEB. Next, I review the role of user comfort in sustainable behaviors, the various approaches toward addressing this complicated topic in past research, and highlight the role of ease of use regarding PEB. After this, I discuss how one's sense of control of his or her devices influence his or her ability to interact with these devices, which leads to increased satisfaction with the built environment and increases the likelihood of PEB. Finally, I present the argument that the HF/E community can make a significant contribution to the research of these concepts in terms of influencing one's participation in PEB and due to our understanding of human behavior, interaction with complex systems, and human-centric design.

Environmental Attitudes

When an individual is choosing whether to engage in a PEB, he or she is making a specific behavioral decision (e.g., turning off the light), even though other options are available (e.g., keeping the switch turned on). Thus, one of the first steps in encouraging PEB involves understanding one's motivation toward participating in these behaviors and the issues that have necessitated them (Kollmuss & Agyeman, 2002). This motivation stems from a variety of individual characteristics that influence how individuals attend to the available environmental information and thus develop particular environmental attitudes (Steg & Vlek, 2009). In order to influence users, one must take into account why these behaviors are important (Lee, 2010), and how different individuals approach this information (Bamberg, 2003; Hines, Hungerford, & Tomera 1986 as cited in Kollmuss & Agyeman 2002). In this section, I provide a review of the literature regarding the origins and development of environmental attitudes, highlight the role of knowledge as a central tenet of attitudes, and discuss their role in predicting PEB.

Origins of Environmental Attitudes

By the time an individual reaches adulthood, he or she has been exposed to countless influences that have shaped his or her environmental attitudes (Kals & Ittner, 2003). Decades of research across environmental and social psychology has indicated that much of this influence occurs during one's early years, through family (Chawla & Cushing, 2007; Eagles & Demare, 1999; Grønhøj & Thøgersen, 2009), friends (Arnold, Cohen, & Warren, 2009; Devine-Wright, Devine-Wright, & Fleming, 2004), school programs (Farmer, Knapp, & Benton, 2007; Jaus, 1984; Zsóka, Szerényi, Széchy, & Kocsis, 2013) media (Ahlberg, 2005; Keinonen, Yli-Panula,

Svens, Vilkonis, Persson, & Palmberg, 2014; Sampei & Aoyagi-Usui, 2009) and environmental campaigns (Lo, Chow, & Cheung, 2012; Moezzi, Gossard, & Lutzenhiser, 2002). From these experiences, individuals begin to develop a complex set of environmental values and beliefs that can provide the rationale regarding why it is or is not important to take part in PEB and drives the likelihood of participation in them (Lee, 2010; Monroe, 2003).

Elements of Environmental Attitudes and Other Related Influences

A large body of work in environmental psychology has focused on determining and categorizing the broad swath of beliefs about the relationship between humans and nature. From this work, two overarching orientations towards the environment have emerged: ecocentrism and anthropocentrism (Milfont, 2007). Both orientations indicate a concern for environmental protection. However, these resources are perceived as valuable for different reasons. Ecocentric individuals believe that nature is valuable for its own sake and should be considered above all else. Anthropocentric individuals believe that nature is only valuable in terms of the resources and benefits it can provide to humans and, when more immediate concerns, such as providing jobs, are called into question, these concerns take precedence over any environmental concerns (Milfont, 2007). For example, ecocentric individuals may fight to preserve a watershed to save wildlife whereas an anthropocentric individual may fight to preserve it for use in watersports. Essentially, both perspectives provide a ‘why’ regarding why it’s important to engage in PEB, but the differences in the rationale make a difference; the ecocentric individuals both demonstrate stronger conservationist beliefs and are more likely to exhibit PEB (Thompson & Barton, 1994).

Similarly, these orientations include a variety of sub-dimensions that also demonstrate similar influences towards (Gifford, 2014); those with values focused on others, such as altruism (concern for the well-being of others), those who regularly engage in prosocial behaviors (those intended to benefit others), and those who hold biospheric values (focused on the health of the planet) and those who view nature as fragile tend to favor conservation, whereas those with self-focused or self-enhancement values tend to see the environment as a source of resources to be consumed (Corral-Verdugo, Mireles-Acosta, Tapia-Fonllem, & Fraijo-Sing, 2011; Kaiser & Byrka 2011; Milfont & Gouveia, 2006; Nordlund & Garvill, 2002; Poortinga, Steg, & Vlek, 2003), and less environmental concern (de Groot & Steg, 2010).

Additionally, research findings further summarized by Gifford (2014) indicate that the following individual differences also have the ability to positively influence how one perceives ecological concerns and increase the likelihood of engaging in PEB: prosocial orientations (Hine, Gifford, Heath, Cooksey, & Quain, 2009), those who value environmental concerns over economic concerns (Heath & Gifford, 2006), postmaterialist values (Oreg & Katz-Gerro, 2006), positive attitudes towards sociocultural diversity and biodiversity (Corral-Verdugo et al. 2009), a strong attachment to one's place (Scannell & Gifford 2013), openness, agreeableness, and conscientiousness (Milfont & Sibley, 2012), a strong consideration of future consequences (Cleveland, Kalamas, & Laroche, 2005), a personal sense of responsibility (Ferguson & Branscombe, 2010) and a moral imperative to protect the environment (Feinberg & Willer, 2013). Furthermore, beliefs about one's personal capabilities also play an important role: self-determined motivation (de Groot & Steg 2010; Pelletier, Tuson, Green-Demers, Noels, &

Beaton, 1998), an internal locus of control (Abrahamse, Steg, Gifford, & Vlek, 2009), and self-efficacy (Maeda & Hirose 2009; Sellers, Fiore, & Szalma, 2013) are all significant predictors of PEB.

Each of these sub-dimensions and other individual characteristics provide a dimension of personality that is well-suited for the reception of pro-environmental attitudes and potential action. However, researchers have also mentioned that a single model that incorporates all of them would be neither parsimonious nor meaningful (Steg & Vlek, 2009). In addition, these components do not drive the behavior alone. Rather, each plays a role in conjunction with a variety of other factors, and must be driven by a pro-environmental purpose. I will now refer to some of the most well-documented connections between these various individual factors, and describe the overlap between these characteristics and how they function together to influence behavior (Gifford, 2014).

Environmental Attitudes in PEB Models

There are several social-cognitive models that incorporate a number of the attitudinal orientations and other dimensions of personality just discussed that have emerged from social science research over the last several decades. For example, cognitive psychology's theory of planned behavior (TBP, Ajzen 2005) posits that one's attitude toward a PEB, based on their understanding, holds a large degree of influence on whether or not he or she will engage in that behavior. However, it is this attitude, together with subjective norms (what behavior considered typical) and one's perceived control over the outcomes that will leads to one developing a behavioral intention and, consequently, behavior. TPB has consistently served as a popular

‘rational’ model that has been used across a large breadth of environmental research and has also demonstrated utility with the inclusion of other constructs, such as self-identity and place attachment (Bamberg & Schmidt, 2003; Chen & Tung, 2010; Whitmarsh & O’Neill, 2010). The values-beliefs-norms theory (VBN, Stern 2000) proposes that that one’s values (altruistic, biocentric, and not egocentric), which have been determined, in part by their environmental knowledge, together lead to an ecological orientation. From this orientation, one gains an increased concern regarding the Earth’s fragility, feels a sense of environmental obligation, and may develop a personal ability to effect change. Together, these factors may, in turn, influence behavior. In goal-framing theory (Lindenberg & Steg 2007), three goal types are suggested to influence the way people process information and act upon it: hedonic (pleasurable), self-interest (focused on the direct benefit to one’s self), and normative (what is considered normal). In this theory, one’s likelihood to engage in PEB to pursue an environmental goal is determined by the degree to which it is perceived as one of these types of goals and their knowledge regarding how environmentally-focused goals also affect them. The reasonable person model (Kaplan & Kaplan 2009) suggests that people are better able to help themselves if they are given the most relevant information, based upon their particular setting. Thus, individual will be more likely to take part in PEB with the proper knowledge regarding their purpose. The human interdependence paradigm (Gärling, Biel, & Gustafsson, 2002) focuses on the competing goals of human development and resource preservation and describes that one is more likely to engage in PEB if he or she better understands humans’ interconnectedness to the planet. Finally, the environmental citizenship behavior model (Dietz & Stern, 2002) emphasizes the important role of one’s locus

of control (derived, in part, through knowledge) in positively influencing their perception of control over the outcomes of their behaviors and likelihood to engage in PEB.

These models each offer helpful, however incomplete, insight into the function of many of the aforementioned personal characteristics in terms of predicting PEB (Gifford, 2014). However, despite their different components of influence and mechanisms of action, there is one concept that is central to their theories upon which they are built: environmental knowledge (Kollmuss & Agyeman, 2002). Across each of the significant predictors of action, there must be some connection to an understanding regarding the importance of their actions.

Knowledge as a Central Tenet of PEB

Knowledge serves as both a foundational precondition to successfully achieving PEB (Frick, Kaiser, & Wilson, 2004) and a complex component of influence (Monroe, 2003). Knowledge neither functions separately from attitudes nor predicts behaviors independently (Stern, 2000), rather it seems to play a role in attitude formation, informing, for example, the orientation of our values (Monroe, 2003), and steering environmental attitudes toward a particular behavior by eliminating information-based barriers regarding its importance (DeYoung, 2000). The mechanics of this action vary across each theory. In some of the models, the role of environmental knowledge is direct and explicit; in the reasonable person theory, the quality and relevance of the information presented is a direct determinant of the behaviors predicted (Kaplan & Kaplan, 2009). However, others models feature, at minimum, a construct that is driven in part by a sense of understanding regarding a particular issue. For example, in TPB, one's sense of the perceived control is an important determinant of behaviors. And, this

particular facet is an extension of Bandura's self-efficacy theory, which includes a component regarding one's "competency" or understanding regarding the behavior in question (Ajzen, 2005). Regardless of these differences in terms of operation, additional factors may influence the process of attitude development and PEB engagement, but do not likely function without a component of knowledge; this understanding is necessary to determine the purpose and direction of the action (Nordlund & Garvil, 2002).

Furthermore, the relationship between general opinions and actual PEB is complex and often difficult to predict (Kollmuss & Agyeman, 2002). Environmental attitudes related to global warming are quite broad and multifaceted, encompassing a range of factors associated with how humans relate to, or use, natural resources, and one's knowledge and attitudes may differ according to the particular issue in question (e.g., use of fossil fuels). Furthermore, since each behavior differs according to the knowledge required and actions involved, individuals may demonstrate varying degrees of PEB depending on the specific behavior (McCarty & Shrum, 2001). Additionally, the influence of the information we receive is best understood when considering the relationship between our environmental attitudes and the specific issues (Nordlund & Garvil, 2002; Steg & Vlek, 2009) and the consequential impact of the behaviors involved (Green-Demers, Pelletier, & Menard 1997).

General vs. Behavior-Specific Knowledge

An individual's orientation towards the environment and his or her likelihood to engage in PEB often varies according to the particular behavior (Cleveland, Kalamas, & Laroche, 2005; Green-Demers, Pelletier, & Menard, 1997). In this same way, past research has indicated that

specific knowledge regarding the PEB in question (such as energy use) and simple conservation knowledge are often most influential in terms of behavior prediction, rather than general environmental knowledge and attitudes (Oskamp et al., 1991). Moreover, because specific attitudes and behaviors do not necessarily provide “spill-over” effects to other PEB (Whitmarsh & O’Neill, 2010), it is important to determine and measure the specific attitudes and knowledge involved as such (Corral-Verdugo, Bechtel, & Fraijo-Sing, 2003). However, a basic understanding regarding climate change importance seems to be a helpful component of environmental attitudes when it can be related to a specific PEB and thereby guide the importance of these behaviors towards the larger goals of conservation, such as how energy conservation will lead to a positive change in the environment (Lee, 2010).

Declarative vs. Subjective Knowledge

Interestingly, self-perceived competence, or subjective knowledge, can provide significant utility, even when an individual has a somewhat inaccurate level of understanding regarding technical details, or declarative (i.e., factual) knowledge (Aertsens, Mondelaers, Verbeke, Buysse, & Van Huylenbroeck, 2011; Ellen, 1994). However, past research has demonstrated that both knowledge relevant to the PEB and perceived understanding, or subjective knowledge, of the subject matter, might be more influential in determining environmental behaviors, particularly when considered together (Kaiser & Fuhrer, 2003). Furthermore, environmental competency regarding both these specific issues and overall climate change understanding is not static, but is constantly changing in response to new information and the influence of other factors involved.

Knowledge Development as an Iterative and Dynamic Process

As described earlier in this section, we are continually exposed to environmental messages throughout our early years, which contributes to our early knowledge and attitude development. However, we continue to receive these messages throughout our lives and, as such, our environmental knowledge not only increases, but changes through the integration of new information, which, in turn, influences how future information is processed and retained (Bandura 1982; 1994; 1997; Sellers, Fiore, & Szalma, 2013). It is important to consider that an individual's perception of any new information presented will be influenced by his or her preexisting attitudes. These attitudes will, in turn, later be influenced by their continuing experiences (e.g., exposure to persuasive messaging), and the likelihood that they choose to engage in that PEB. Essentially, one's understanding regarding an issue and their rationale for participation in the behaviors associated with it set the stage for their reception to the messages they receive next (Bamberg & Moser, 2007). Since, as discussed above, environmental campaigns are a common source of the environmental information we receive, these programs are often influential in our ongoing attitudinal and behavioral development.

Environmental Campaigns

In addition to considering the development of environmental attitudes and understanding the influence of specific types of PEB-related knowledge, the source of information and specific content provided through environmental messaging must also be taken into account. Since attitudes are one of many influences and characteristics that interact to drive our actions, but are not a direct determinant of behaviors, (Ajzen & Fishbein, 1977; Scott & Willits, 1994), a large

body of research has focused on developing the most effective and compelling methods to understand and leverage pre-existing knowledge and attitudes in order influence PEB. In this section, I summarize the research findings on campaign strategies that have successfully increased PEB by targeting attitudes and underscore the importance of knowledge in these efforts.

Source of Message

One of the initial considerations and primary predictors of information attenuation in terms of PEB campaigns is the source of information. The elaboration likelihood model (ELM) from social psychology describes two routes of influence that can be utilized through persuasive communication (Petty & Cacioppo, 1986): in the central route, attitudes are changed via thoughtful consideration and evaluation of the merits of the presented information, meanwhile the peripheral route employs cues that are associated with a particular message, such as an endorsement, expert opinion, or an attractive source. Past research suggests that utilizing both routes to persuasion (i.e., a highly credible source coupled with a tailored message to be meaningful to the target audience) is an effective means of persuasion for public service announcements (PSA, Bator & Cialdini, 2000). Similarly, participation in energy programs increased when information was provided by word-of-mouth and through community groups, and when the sources of information seemed credible (Stern, Aronson, Darley, Kempton, Hill, Hirst, & Wilbanks, 1987).

In addition to utilizing both routes of persuasion, these strategies also leveraged another important factor: normative beliefs. These beliefs entail what individuals believe other people in

their community are doing and have been demonstrated as an influential mechanism in encouraging PEB (Corral-Verdugo & Frias-Armenta, 2006). In order to successfully continue this norm-centered communication, participants may be encouraged to pass on the information to one another to further spread awareness (Yates & Aronson, 1983). Beyond awareness, this type of behavior can serve to designate the participants as “green leaders” in the specified action, which encourages increased personal PEBs through their elevated self-perception (Burn, 1991).

In this way, the campaign messages both targeted actual knowledge regarding the importance of these efforts, while also influencing the other ancillary factors that influence environmental attitudes to maximize the impact of the message.

Effectiveness and Awareness of Campaign Information

Popular environmental behavior campaigns have often employed a community-based social marketing approach (McKenzie-Mohr, 2000), frequently with messages such as “Thinking globally, acting locally” (Oskamp, 2007). Unfortunately, terms such as “sustainability” and “conservation” are abstractions that are difficult to relate to everyday life (Brown, 2009) and these types of campaigns have demonstrated short-term PEB changes that were limited in impact (Nickerson & Moray, 1995). Attitudes toward a particular PEBs are a better predictor than general environmental attitudes and, correspondingly, public educational efforts designed to target specific behaviors are more effective at encouraging a variety of PEB than campaigns to increase knowledge of widespread environmental degradation (Arbuthnott, 2009).

Past social psychology research has demonstrated that when individuals report a high level of perceived subjective understanding of the subject matter, such as energy literacy, they may be more likely to engage in self-reported behaviors (such as energy conservation behaviors), than if they had more accurate declarative knowledge alone (Costanzo, Archer, Aronson, & Pettigrew, 1986). Furthermore, the likelihood of these individuals to engage in these behaviors increases further when they do report relevant knowledge about that specific PEB. Subjective understanding is often much lower than actual understanding, in terms of technical details regarding sustainability. However, what is more important than declarative knowledge is that the information presented is perceived, favorably evaluated, understood, and remembered. Essentially, the individual must actually be aware of the opportunity to act. In order to increase knowledge and awareness in this way, information is best conducted through vivid communication and that losses (such as reduced energy use or money spent) is emphasized rather than gains (Coltrane, Archer, & Aronson, 1986; Gonzales, Aronson, and Costanzo, 1988; Aronson & Gonzales, 1990). Furthermore, as this understanding intersects with individual positional factors, such as ability to use devices (discussed in the next section), and result in an increased likelihood of PEB engagement.

Cueing Pre-Existing Knowledge

Individuals receive information from a variety of sources and develop complex environmental attitudes and knowledge through iterations over the course of their lives. Once this information is initially presented and relayed, its influence may dissipate over time and, in this way, it is often helpful to leverage pre-existing knowledge and attitudes to remind

individuals about these issues. One particularly effective method involves fostering cognitive dissonance, or a sense of inconsistency between one's thoughts, beliefs, and/or actions (Osbaldiston & Schott, 2011), by asking individuals about their environmental attitudes and then pointing out the discrepancy between their reported values (such as preserving and protecting the planet) and their lack of regular participation in behaviors that address these concerns. In this way, individuals may change their behaviors in order to avoid feeling like a "sustainability hypocrite" (Burn, 2013). Successful methods have included reminding students of past behaviors (such as not conserving water) that were not in line with their attitudes, asking them to make a public commitment to change behaviors going forward, and, as an extension of both dissonance as well as influence of word-of-mouth information, asking that participants encourage others to make the pledge as well (Aronson & Gonzales, 1990; Dickerson, Thibodeau, Aronson, & Miller, 1992). In order to develop ongoing behaviors, prompts can be quite effective in changing behavior (Steg & Vlek, 2009), but these must be presented in a way that is not obtrusive (Aronson & O'Leary, 1982). For example, individuals may be more likely to conserve water or energy if signs with messages that remind them to take shorter showers or turn off the lights are provided, but they may also become resentful towards these behaviors if the signs are large and get in the way. Essentially, individuals need to be reminded why it is important to take part in PEB and simple reminders or cues can assist in creating awareness and reactivating their pre-existing knowledge regarding the impact of their actions.

Summary of Environmental Attitude and Campaign Research

The research reviewed in this section indicates that we start forming environmental attitudes at a young age through exposure to numerous sources from the norms of family and friends to the technical information provided in campaigns. Additionally, there are a variety of influential factors that determine these attitudes and our likelihood to engage in behaviors associated with them. However, across theories, knowledge is the common denominator; it both shapes our attitudes and steers them toward potential action. Although knowledge alone is not a direct predictor of PEB, it is a necessary precondition for its action. Furthermore, knowledge is the strongest predictor of behaviors when it includes behavior-specific information tied into the general message of conservation and when individuals feel confident about this knowledge, even when this means that their subjective knowledge is higher than actual declarative knowledge (Major, 2000). We continue to develop our knowledge and attitudes throughout our lives and can be more or less effectively influenced by behavioral-change campaigns depending on their source, message, and our previous level of understanding, and awareness of these opportunities (Osbaldiston & Schott, 2011).

The Built Environment

Across the breadth of social psychology and environmental psychology research discussed, the concept of environmental attitudes and knowledge has been largely regarded as key instrument in providing the rationale for ‘why’ a behavior is important. Both the models reviewed and the campaign strategies discussed focus almost entirely on this impact-oriented view of knowledge. Little attention has been given to the built environment in which these

behaviors are to occur, particularly in regard to campaigns, and the devices through which they are achieved. However, several researchers have called for the investigation of contextual factors and barriers toward specific behavioral action (Kaiser & Fuhrer, 2003; Monroe, 2003; Steg & Vlek, 2009). Generally, conservation efforts can become more difficult when an individual lacks basic knowledge related to energy fundamentals in the home or at work (Brewer, 2013). More specifically, the concepts of procedural knowledge (Levine & Strube, 2012), user comfort (Hua, Oswald, & Yang, 2011), and control (Brown & Cole, 2009) all demonstrate potential in terms of addressing the ‘how’ component of behavioral adoption. In this section, I will review these three concepts and their role and impact in terms of PEB.

Procedural Knowledge

It is clear that individuals must have an understanding regarding ‘why’ PEB are important in order to pursue them and that this mix of declarative and subjective knowledge will influence their later reception of messages regarding PEB (Nordlund & Garvil, 2002). However, despite their attitudes or intentions, once individuals are confronted with the actual device, they must know ‘how’ to use it and what steps are involved in executing these behaviors in order to achieve their sustainability goals (Steg & Vlek, 2009; Tuomey, 2009). For example, researchers have argued that curricula for energy literacy, for example, should include guidance regarding day-to-day-behaviors (DeWaters & Powers, 2011). Although significantly less research has focused on the role of procedural knowledge in this capacity, past research has indicated that knowledge regarding how to carry out a behavior has been demonstrated as a strong predictor of PEB (DeYoung, 1989; Levine & Strube, 2012).

Training and Adaptability

With regard to learning procedural information and how knowledge influences behaviors, research in the field of engineering has demonstrated the important role that training can play. In some buildings, training was used to ensure occupants relied little on artificial lights in public areas (Li et al., 2014). For example, in building zones with sufficient natural daylight (e.g., desks on office perimeters), occupants were trained to only rely on natural light when necessary. Once these occupants understood how to adapt to utilize their natural lighting, they were less likely to use artificial lighting, thus saving money and electricity, without negatively impacting their work. The focus of such training should be specific to developing the knowledge necessary to make informed energy use decisions as an individual (Brewer, 2013; Day & Gunderson, 2015).

More importantly, research suggests that procedural knowledge can influence whether energy consumption is influenced by design features. When looking at enhanced lighting features, energy consumption depended upon the degree to which occupants were aware of lighting controls and had been trained on them (Doulos, Tsangrassoulis, & Topalis, 2007). Furthermore, when users are aware of their opportunities to adapt, their reported discomfort is reduced (Kwok & Rajkovich, 2010). Adaptive opportunities range from clothing options for the workplace, to control of thermostats and windows, all of which can reduce thermal stress. For uncomfortable individuals, information provided from the building manager regarding how one can become an active user and influence the system, may empower he or she to make changes, such as adjust the temperature accordingly (Brown, Dowlatabadi, & Cole, 2009). When users are aware of design features and their intent is made clear to them, thus improving their declarative

and/or subjective knowledge, occupants are happier and more likely to engage in PEB (Deuble & de Dear, 2012).

However, despite the promising findings regarding the potential of training for encouraging PEB and increasing associated adaptive behaviors, there is very limited research regarding the degree to which occupants understand how to use the devices in their built environment or the necessary components of training. Some researchers have suggested that training is designed with a deliberate focus on determining the needs of the user, in terms of both the breadth and relevance of information required to most effectively utilize the features of a high-performing building (Steinberg, Patchan, Schunn, & Landis, 2009). Indeed, others have found that effective occupant control training led to improved performance and satisfaction in energy efficient spaces (Day & Gunderson, 2015). Yet, the majority of research has incorporated an occupant behavior prediction model for systems such as lighting and temperature based on behavior patterns alone and that does not include any explicit training for occupants nor opportunities to address their concerns (Gunay, O'Brien, & Beausoleil-Morrison, 2013). Finally, based on the current available research, there is no known data available regarding the influence other sources of procedural knowledge, such as the frequency of seeking out information regarding how to use energy devices through a user manual, online search or speaking to others, or the effectiveness of this information.

The Influence of Declarative and Subjective Knowledge on Interactions Within the Built Environment

The impact of skill training and likelihood of one utilizing his or her procedural knowledge, however limited, to engage in PEB is still largely influenced by their understanding regarding why these behaviors are important in a given context (Steinberg, Patchan, Schunn, & Landis, 2009). Researchers have found, with the proper education regarding why the features are being installed and how to use them, as well as the potential benefits, can demonstrate a “forgiveness factor” for their behavioral experience (Brager, Paliaga, & de Dear, 2004). That is, when occupants do report some level of environmental concern, they tend to tolerate more green building features, such as natural ventilation via operable windows, and were more likely to overlook conditions that were less favorable than other occupants.

What is important to recognize is that an understanding regarding the importance of a building’s efficient or “green” features often allows users to overlook mild discomfort or differences in preference due to supporting the larger goal of sustainability. Occupants of buildings with green features often report increased comfort and satisfaction, however, in the case where there is a loss of productivity and building success due to being confronted with new and unfamiliar devices or building design can be overturned if LEED representatives and building managers make occupants aware of exactly how the benefits for the environment are outweighing the costs to their personal comfort (Deuble & de Dear, 2012).

However, some individuals might attend to the sensation of otherwise uncomfortable temperatures differentially, depending on either their goals for interacting with their environment or personal preferences, for example.

Comfort

As with all behaviors within a given built environment, comfort is a primary driver of action (Brown, Dowlatabadi, & Cole, 2009). The concept of comfort has two main components to consider. First, the user will be more likely to engage in a behavior if it will result in a satisfying level of comfort (Brown, 2009). Second, the user will be more likely to carry out a behavior if the action involved is easy and convenient (Ajzen, 1991).

Two Approaches to Comfort

When an individual is choosing whether to interact with the built environment to meet their basic comfort needs, a preliminary consideration regarding whether she or he will engage with an amenity is their belief whether this interaction will result in a satisfying level of comfort, the first component of comfort. If the individual believes that no change will occur or that the change will be unsatisfying, they will be less likely to carry out the behavior, since it will not allow them to achieve the desired goal of improved comfort (Brown, 2009). In the green built environment, specific issues related to user comfort have typically included lighting, sound, temperature, and air quality that have been evaluated through traditional engineering approaches that utilized post-occupancy surveys in order to determine user satisfaction across these domains (e.g., Dolezal & Spitzbart-Glasl, 2015; Zhang & Altan, 2011; Zuo & Zhao, 2014). Although

occupants of green buildings report high levels of comfort and satisfaction (Brager & Baker, 2009), due to the vast differences in personal preferences across groups of individuals as well as unique factors within any built environment (e.g. Li et al., 2012), it is not typically feasible to determine an ideal universal design or setting that would function best for all individuals and in all circumstances. Rather, it is more important to provide a variety of control settings that can be tailored to the individual and setting (Tosi, 2012).

As discussed above, with improved knowledge and control regarding these features, individual users often express a “forgiveness factor”, reporting higher levels of satisfaction than in previous responses, although nothing has changed in the ambient environment. Research drawing from the fields of health science and environmental psychology have also demonstrated that exposure to natural environments have direct and positive impacts on well-being (Bowler, Buying-Ali, Knight, & Pullin, 2010) and that the act of opening or even just being able to look through windows to experience exposure to the outside environment can provide a degree of these benefits to one’s level of physical satisfaction. Thus, a slightly higher temperature might be tolerated if it also carries with it increased physical satisfaction in the visual experience of exposure to the outdoors. Furthermore, from a cultural perspective, Li et al. (2014) found that some “place high value on fresh air and have a relatively broader indoor thermal acceptable range than is typical” (p. 406).

As such, research is better focused on investigating the degree to which individuals have the knowledge and sense of control required in order to utilize their amenities in order to achieve

their desired level of comfort, or the second component of comfort. As such, subsequent discussion of comfort throughout the rest of this paper will refer to this approach.

Ease of Use

In order to achieve one's desired level of comfort, the user must interact with an amenity. Even if a user feels confident that, with proper manipulation of the device, their resulting comfort could be achieved, if the *process* of engaging with a device seems difficult or cumbersome, it will often be avoided. Thus, issues such as ease of use need to be considered together with factors regarding the process of interaction, such as occupant training of controls, such as lighting features (Hua, Oswald, & Yang, 2011). The concept of ease of use has been examined in some studies related to environmental sustainability. In a study of occupants of a new facility, Doulos and colleagues (2007) found that reductions in energy consumption related to lighting conditions depended upon factors such as the ease of changing lighting conditions.

Despite ease of use being a relatively under-studied area of research, HF/E theory and methods offer a variety of robust, user-centered approaches for studying how to improve both sustainable behaviors and the user experience (Hedge & Dorsey, 2013; Sellers & Fiore, 2013; Zink & Fischer, 2013). Indeed, a design that allows for environmentally friendly behavior based on easy, efficient, almost passive choices may reinforce long-term behavioral changes for those who are already environmentally inclined. Furthermore, it may encourage more ambivalent individuals to make similar decisions, because, effort-wise, it is the easiest, and thus most comfortable, thing to do (Phillips, Sellers, & Fiore, 2010; Weir, 2013). In order to maximize

comfort and ensure long-term PEB, the critical research issue is understanding the features and behaviors involved, why they are important, and how to best utilize them (Deuble & de Dear, 2012). Furthermore, with insight and understanding regarding user-reported knowledge and habits, design innovation can support existing patterns of energy consumption and style and anticipate future needs and accommodate them appropriately (Tosi, 2012). Since building design and amenities offered play an influential role in terms of determining comfort, environmental sustainability presents an important opportunity for HF/E to examine ease of use through design.

In addition to the ease of using a device, when there is a degree of perceived control of that which causes discomfort (being able to choose to sit in sun or shade, for example), occupants are more tolerant of variations and have less negative reactions. Interestingly, in some studies, occupants did not even need to actually move from a space that was reported as uncomfortable (such as sitting in direct sun), what mattered more in determining their reported satisfaction was merely their ability to choose to do so (Nikolopoulou & Steemers, 2003). Nonetheless, it is not reasonable to consider how to design an environment that can optimize all things for all people. As such, others have argued that even more direct control be provided to the occupants.

Control

Even during the early years of designing for sustainability, a distinction was made between the “active” and “passive” roles that occupants can play in building operations (Hartkopf, Loftness, & Mill, 1986). Specifically, when building users are treated as “passive”

recipients of the buildings' ambient conditions with little room to intervene to just the features of the built environment to suit their needs, this lack of control can lead to dissatisfaction on the part of users. Early research found that the availability of personal control of temperature extended beyond just thermal comfort. For example, when occupants are given control over temperature regulation, energy efficiency improved because use aligned with needs as opposed to merely maintaining a uniform temperature that was externally imposed (Hawkes, 1982). Similarly, when occupants had control over air speed, they were found to be more tolerant of wider temperature variations (Bauman, Carter, & Baughman, 1998). These were in contrast to occupants merely playing a passive role in their experience (Baker & Standeven, 1996). Relevant to this dissertation, Brown and Cole (2009) have argued that the field needs to embrace the idea that building occupants can and should play an active role in helping to maintain energy utilization in their building, as opposed to being perceived of as a passive recipient of the conditions provided by the built environment.

Types of Control Across Devices

Numerous studies have shown how incorporating building operators in an active role over control systems can have a positive impact on energy utilization (see Zhao et al., 2014). This has included studies examining how individualized control systems for air conditioning, lighting, and power outlets can improve energy utilization (e.g., Yun et al., 2013). In their analysis of energy utilization in high-performance buildings, Li et al. (2014) noted that plug loads (i.e., how much energy is drawn from devices plugged into power outlets) and artificial lighting typically account for the largest part of energy savings and that some design features

have specifically taken advantage of this potential with regard to occupant behaviors. For example, in one building studied, artificial lighting was designed to be controlled directly by building staff and could even be independently controlled for each row of office desks. Others have also found that there tends to be more user satisfaction with increased control over lighting (Hua, Oswald, & Yang, 2011) and that buildings without override controls or choices for manual controls were associated with dissatisfaction among a majority of occupants as most preferred at least some level of control (Doulos et al., 2007).

However, much of the research in this area still does not take into account occupant behaviors or considers rather simplistic approaches when doing so. When simulating the impact of personal control features such as “operations on blinds, lights, windows, set point temperatures, fans, and personal clothing insulation” (p. 226, Bonte, Thellier, & Lartigue, 2014), models have demonstrated that user behaviors can have a significant impact on energy variation. These researchers suggest that the combined impact of all these individual behaviors can lead to vast discrepancies between simulations (not accounting for occupant behavior) when designing green buildings and underscores the importance of understanding occupant behaviors within the built environment. Conversely, studies have also found that improved complaint systems, where occupants can report their comfort can positively impact energy utilization (e.g., Goins & Moezzi, 2013). Additionally, manipulations of workplace culture (e.g., flexible dress codes and breaks) can help control experience within the ambient environment or the provision of areas within the building where thermal conditions vary (see de Dear & Brager, 2002). Similarly, the “forgiveness factor”, in which building occupants express a higher level of reported satisfaction

when the sustainable purpose of a building's features are explained, is often the strongest when occupants also have some level of personal environmental control (Brager, Paliaga, & de Dear, 2004).

As with procedural knowledge and ease of use, user control further highlights the need for HF/E researchers to become more engaged in such research and illustrates the importance of user-focused design for improving PEB interactions with the built environment.

Summary of Built Environment Research

The devices provided within a given built environment and one's experience of interacting with them provide the foundation for 'how' users perform PEB within that space. Research has demonstrated that a basic understanding regarding how to use the specific features is important, but findings regarding training are limited and little is known regarding other potential sources of information. The degree to which these users also have a strong sense of the importance regarding these behaviors (as discussed in the previous section) can also influence their interaction with these devices and potentially provide a "forgiveness factor". Next, the ease of using a device largely predicts the behavioral adoption associated with it and this concept has proven to be more useful and practical than comfort as a result. Finally, the ability to control a device seems to also drive the potential action of a PEB.

Summary of Conceptual Overview

When considering the relationship between HF/E and knowledge of the environment, an improved understanding regarding the relationship between environmental attitudes and PEB is

one gap readily filled through application of HF/E methods for understanding the motivation (or ‘why’ component) behind PEB. In the context of energy behaviors within a building, an understanding regarding how users perceive the process of interacting with devices in their built environment (the ‘how’ component), specifically regarding procedural knowledge, ease of use, and control, is another gap readily filled through application of HF/E methods.

I argue that these approaches to both can be integrated to address an important set of gaps between research within the social sciences and engineering approaches within the context of environmental sustainability. Specifically, through the integration of concepts and methods from allied disciplines, and by studying the relation between humans and the built environment, this research can help us understand how to maximize PEB through addressing environmental attitudes; declarative, subjective, and procedural knowledge; ease of use; and control. Next, I further contextualize this research through description of current outreach initiatives related to environmental sustainability at UCF.

Contextual Overview

In this section, I describe a subset of sustainability efforts implemented in the real world. My goal is to provide background on representative examples of the types of modifications to the built environment that have been implemented, the benefits and challenges that these modifications present, as well as the types of behavioral interventions that have been developed. As discussed, the purpose of this dissertation is to integrate these approaches for the purposes of understanding the interactions of the built environment with behavioral interventions and the

types of psychological processes discussed earlier in my proposal. First, I provide a general overview of initiatives (e.g., “green buildings”) and amenities (e.g., “smart thermostats”), both of which are important parts of the context for this research. I then describe how these are currently being implemented at UCF, along with behavioral interventions meant to raise awareness and use of such efforts.

Green Buildings and Related Programs

Crossing the fields of engineering, architecture, and design, is the concept of high-performance buildings. This is a global term that captures buildings that are classified as “green” or “sustainable” which are considered to be low-energy or low-carbon-footprint buildings (Li, Hong, & Yan, 2014). Various certification programs, the most common being LEED (U.S. Green Building Council, n.d.), provide guidelines for the design, construction, operations and maintenance in order to ensure that the building is constructed and operates in a way that supports environmental sustainability. Buildings attain credits by using sustainable and non-toxic materials in construction, minimizing water and energy use (and utilizing renewable energy whenever possible), incorporating aspects of the natural environment (such as landscaping with native plants) and promoting various PEB (such as bicycle transport), among other factors. The green building market has grown tremendously, from \$10 billion in 2005 to an estimated \$85 billion in 2012, with expectations of exceeding \$200 billion by 2016 (Weaver, 2013). In addition to the obvious benefits to the environment, these buildings also demonstrate increased profits and market values for businesses (von Paumgarten, 2003), and, often, increased health and satisfaction for occupants (Younger, Morrow-Almeida, Vindigni, & Dannenberg, 2008). As with

other colleges and universities, UCF has pledged that all future building construction and renovation will meet LEED certification standards.

Some have examined how occupant behavior needs to be factored into such designs. For example, Li et al. (2014) found designers leveraging occupant preference for natural light and natural ventilation so as to minimize a need for artificial light or mechanized cooling systems. Studies in this area have noted that more than just the addition of efficient technologies and design is needed. They note that energy performance can only be maximized through careful attention to occupant behaviors (Li et al., 2014). Similarly, providing feedback on energy use influences the effectiveness of sustainability designs and, furthermore, may help lead to the development of new habits (Fong & Lee, 2012; Katzeff et al., 2013). Unfortunately, in many large settings, such as multifamily housing or office buildings, it may not be immediately feasible to replace or complement all existing devices with feedback devices, such as smart meters, or more automated devices. For these spaces, little is known regarding the influence of an attitudinal or educational approach toward improving occupants' interactions across a variety of device types or how these types of may approaches can impact energy conservation behaviors.

Finally, from a more macro perspective, developers and designers are considering factors such as those described above when embedded in particular local climates (e.g., temperatures in Florida during summer) and how variations in climate context need to be factored into design decisions (Li et al., 2012). Generally, occupants of green buildings report having more favorable opinions of such environments than less energy efficient environments (Abbaszadeh et al., 2006; Brager & Baker, 2009). But, occupants do still need to maintain preferable levels of air quality

and, in some situations and climates, green buildings can produce problematic effects such as less satisfaction with the built environment if it offers unsatisfactory temperature or ventilation in hot and humid tropical regions, for example (Ravindu et al. 2014).

Design and Amenities

In order for green buildings to be optimally effective, both the general design and specific amenities must be tailored toward the comfort of the users. Specifically, user comfort is determined by two factors. First, the user will consider whether an action will result in a satisfying level of comfort, such as whether to open a window, rather than using air conditioning, or (for more advanced technology), utilizing an ‘auto-adjust’ feature on a smart thermostat, in order to achieve a preferred temperature (Brown, Dowlatabadi, & Cole, 2009). If one does not believe that the more environmentally sustainable option (e.g., opening a window) will result in the desired level of comfort, or if the use of a certain feature (such as an adaptive smart thermostat), is actually causing the discomfort, this PEB will likely be avoided (Brown, 2009). Next, the user will consider the action behind the behavior itself. If a particular behavior is perceived as inconvenient or cumbersome, it will also be avoided (Ajzen, 1991). For example, researchers have demonstrated that the perceived accessibility to a nearby location may determine whether one may choose to walk, rather than drive (Cao, Mokhtarian, & Handy, 2007) and the convenience of recycling bin placement influences whether one chooses to place an item in the appropriate receptacle (Robertson & Walkington, 2009). However, the ease of the process of conducting general energy-saving behaviors has not been tested in the same way.

To date, the majority of the research regarding occupant satisfaction and PEB within green buildings has provided a holistic comparison of these spaces versus their conventional counterparts. This research has largely utilized traditional post-occupancy surveys that are focused on comfort as a result of thermal (Zhang & Altan, 2011), lighting (Zuo & Zhao, 2014), acoustic (Dolezal & Spitzbart-Glasl, 2015), or indoor air quality (Xiong, Kroghmann, Mainelis, Rodenburg, & Andrews, 2015) conditions and their influence on worker productivity (Ries, Bilec, Gokhan, & Needy, 2006; Singh, Syal, Grady, & Korkmaz, 2010) rather than the process of using devices within these spaces (Paul & Taylor, 2008). These surveys also do not typically include a component of procedural knowledge nor reported control over these devices. Furthermore, the PEB are often measured through various performance outcome measures (such as energy and water use or recycling rates), rather than the occupants' motivation or understanding toward pursuing these specific behaviors (Hoffman & Henn, 2008; Ruano & Cruzado, 2012).

Sustainability Initiatives on Campuses and at UCF

The University of Central Florida is actively involved in transition towards environmental sustainability, with a pledge to become carbon neutral by 2050. Sustainable UCF oversees, manages, and implements programs and projects designed to meet this goal, as well as maintains pledged involvements as a signatory in national programs designed to provide resources, encouragement, and accountability for climate-related commitments, such as the American College and University Presidents' Climate Commitment. In addition to the development of projects such as a solar-powered parking garage, a central heating and cooling

plant that produces a third of the University's power, and the supervision of all building construction in order to ensure that LEED standards are met, the department also runs programs designed to promote student PEB on campus, the largest of which is the Kill-A-Watt Competition. From a scientific standpoint, this program occurs within the built environment (the individual residence halls), which influences user comfort. Additionally, this campaign is designed to influence the other components on which I have focused; that is, cueing declarative and subjective knowledge and a general sense of control over their own behaviors. I next briefly describe a representative subset of energy reduction competitions at other universities, and then describe the primary program at UCF on which this dissertation will focus.

Energy-Saving Competitions on University Campuses

One popular form of sustainability engagement for students living on college and university campuses is an energy-saving challenge. In these, residents in different housing communities, or different floors, within a single housing building compete to save the most energy across a short period of time (Hodge, 2010). Since campus housing costs include a flat-rate for utilities and do not vary based upon energy use, it is especially important that outreach efforts for these programs detail the relevant information (or user knowledge) regarding the importance of taking part in the campaign from an environmental impact perspective, as well as any incentives or rewards, in order to ensure strong participation (Brewer, 2013). Another key feature of these competitions includes regular energy performance feedback for on-going motivation and clarity regarding where each building stands in terms of their ranking in the competition (Hodge, 2010).

Successful campaigns have included Oberlin College's Energy Competition (Petersen, Murray, Platt, & Shunturov, 2007), Campus Conservation Nationals, Western Washington University Go for Green Challenge (Mankoff et al., 2010), University of Southern California Ecolympics (Sintov, 2011, as cited in Brewer, 2013), and University of Hawai'i at Manoa's Kukui Cup Challenge (Brewer, 2013). Some have tried to modify student behavior through additional challenges related to the competition. For example, Brewer (2013) developed online challenge games to study their impact on factors such as energy literacy as well as energy utilization. Although there were improvements in knowledge about energy, there was little evidence of a correlation between the challenge games and changes in energy consumption. But Brewer noted that this may have been due to an inadequate base-lining with participants in the dorm rooms being studied. Additionally, it should be noted that similar campaigns have been successful in residential areas including non-college students across a wide range of demographics (Dillahunt, Mankoff, Paulos, & Fussell, 2009; Kamilaris, Kitromilides, & Pitsillides, 2012).

Kill-A-Watt Competition

For the last eight years, UCF has participated in a similar campus-wide campaign developed to encourage energy reduction called the Kill-A-Watt Competition. Begun in 2006, the Kill-a-Watt Competition requires that residents collaborate in such a way that, collectively, they reduce their building energy usage. To be part of this competition, participating buildings have to achieve at least a 20% reduction in energy usage (relative to a baseline) at the completion of the competition. Residents are provided with feedback halfway through the competition

regarding their building's energy performance relative to the baseline as well as their ranking compared to the other housing buildings. Those residing within buildings that have reduced the most energy by the end of the competition are eligible to submit an essay detailing what they did to save energy in order to be considered for scholarships provided by SGA. Relevant to my earlier arguments, this program relies heavily upon campaign awareness, cueing pre-existing knowledge by providing suggestions regarding how to participate (such as turning off lights, turning up the temperature, and unplugging electronic devices) and information regarding why the campaign is important for energy reduction at UCF by detailing the history and reputation of the campaign and its successes in support of PEB, as well as the scholarship prize incentives, for achieving a common goal of building-wide energy reduction.

Integrating Concepts and Context

Although programs aimed at reducing energy, such as the Kill-A-Watt Competition, are highly relevant areas for potential impact, since electricity consumption drives nearly half of all CO₂ emissions (U.S. Energy Information Administration, 2016), participation in these programs may be somewhat limited or hindered depending on the design on the dorm and the amenities available. While this campaign has the potential to tap the important components of declarative and/or subjective knowledge and control, as discussed, from the perspective of HF/E, “greenness” must be done in a human-friendly way, and thus comfort-providing way, or energy use will likely be unchanged (Collins, 2010). In this case, differences such as whether the dorm room has easily accessible outlets for unplugging devices, has motion sensor lighting, has a programmable thermostat, and, perhaps most importantly, how these features are perceived in

terms of comfort and usability, will play a large role in the ability and desire to engage in energy reduction behaviors and take part in these campaigns.

I argue that these factors must be simultaneously considered. Specifically, the ability of campus campaigns to influence user knowledge and control, and awareness of the sustainability context (e.g., the comfort afforded by the built environment), must be considered together to effectively understand involvement in campaigns and the execution of other PEB on campus as well as to help identify areas for improvement. In the following section, I summarize the approach I use in the current research to study these factors in the student housing population at the University of Central Florida. Because this area of research is still developing and little attention has been given to several of the key factors explored in this study, a decision was made to focus on a preliminary examination of these factors through an initial survey development and validation. This, then, represents a stepping off point for broader and deeper analyses of features and concepts in future research that can help move the field of HF/E towards an interdisciplinary understanding of environmental sustainability behaviors within the built environment.

Initial Knowledge, Comfort, and Control

Available Amenity

To begin, the range of possible behaviors for each individual is dependent upon the amenities available to them. The process of conducting energy-related behaviors within a built environment, such as turning on the lights when he or she enters a room, requires an option to intentionally change the current state of the built environment (such as whether the lights are

turned on or off). Since we are focusing specifically on behaviors that are relevant for participation in the Kill-A-Watt Competition, these amenities will include lighting fixtures, thermostats, and power outlets. Specifically, we are interested in the degree to which an individual is capable of controlling these devices in order to engage in these behaviors. In terms of lighting devices available in on-campus housing at UCF, this would mean the difference between a manual switch (for which they have total control), an automatic switch (for which they have no control), and an automatic switch with a manual option (for which they can make the choice regarding whether or not to utilize the automatic feature). For thermostats, all devices on campus provide the opportunity for some control of temperatures (i.e., they are not fully automated), but there is a limited range of temperatures provided (e.g., users cannot program their thermostat to 60 degrees, as is possible in some residential spaces). Finally, for power outlets, the range of possible behaviors would be dependent upon the number of devices and their locations (whether or not they are accessible based on the design of the room and layout of the furniture).

Kill-A-Watt Behaviors

The outcomes of interest are the behaviors relevant for saving energy and taking part in the Kill-A-Watt Competition, hereafter referred to as “Kill-A-Watt behaviors”. These behaviors include turning off lights when leaving a room, turning up the temperature on the thermostat, and unplugging electronic devices. These behaviors do not imply participation in the actual Competition (which will be discussed later), but taking part in the behaviors that would

contribute to overall energy savings for their residence hall building and subsequently serve as the basis for participation in the Competition.

H1a: The availability of adjustable amenities will be positively related to participation in Kill-A-Watt behaviors.

User Knowledge Regarding How to Use the Amenity

In order to use most devices, a basic level of user knowledge is required, which is determined by both the features of a specific device, as well as their understanding regarding how to use them. Typically, tenants move into a new residence with very little explanation or education regarding the building's design, how to use the features, or how these features influence energy use (Brown & Cole, 2008). Thus user knowledge is dependent upon the particular amenity in question and can originate from prior experience, trial-and-error with the device, word-of-mouth or demonstration from a roommate or resident advisor, etc. The origination of this knowledge is not as important as understanding a baseline level of this procedural knowledge so as to demonstrate whether or not it has been influenced since the start of the Kill-A-Watt Competition.

H1b: User knowledge regarding how to use an amenity will be positively related to participation in Kill-A-Watt behaviors.

Information Seeking Behaviors

While the aforementioned factors provide grounding for understanding the relationship between level of comfort and interaction with the environment, I additionally consider information seeking behaviors on the part of the user. Depending on the user's prior level of knowledge with a device, he or she may seek out additional information regarding how to use the amenity. This could be as simple as asking a roommate how to use the thermostat or as intensive as an online search regarding how to control the features of the specific model of light switch in their room. Research has indicated providing knowledge through user education regarding the features of a building is crucial in order to influence PEB (Tuomey, 2009), yet there is no explicit research describing how individuals may obtain information about their amenities if the instructional information provided to them was insufficient or nonexistent. However, we hypothesize that user knowledge will be positively be related to the degree to which the individual finds this information helpful.

H1c: Information seeking behaviors will be positively related to user knowledge.

User Perception of Ease of Use with Device

The degree to which an individual feels a sense of comfort or ease of use with utilizing a device will likely influence the way the individual interacts with the device. In this case of power outlets, one issue in this area may include inconvenient locations. If the individual feels that it is too much effort to access most of the power outlets available to her, she will be less likely to unplug her devices on a regular basis. However, increased user knowledge can influence the

perception of ease if, for example, she was aware of how to best utilize a powerstrip to maximize the location of the most convenient power outlet and to easily turn off all devices at once. With this knowledge, users would be more likely to find the devices easier to use and engage in Kill-A-Watt behaviors. At the most general level, I hypothesize that individuals will not likely engage in behaviors that compromise their comfort, particularly if these behaviors require additional effort (Hassanain, 2008).

H1d: User perception regarding ease of using the amenity will be positively related to Kill-A-Watt behaviors.

User Knowledge and Ease of Use

A user's level of procedural knowledge will increase their understanding regarding its features, which will affect his or her ease of using the device.

H1e: User knowledge will be positively related to ease of use.

User Perception of Ability to Control Device

Regardless of the range of features, if the user does not feel a sense of control over the device, these features are not likely to be used, and subsequently, Kill-A-Watt behaviors may be avoided. For example, if the user does not feel that he can control their automatic lights by utilizing the manual option, he may be more likely to keep the lights in automatic mode. In this way, the ease of use of the device would be related to user control because the individual would likely describe the task of utilizing this feature as difficult. However, increased user knowledge

may be related to the perceived ease of use; if the user was aware that he needed to hold down the switch for a few seconds in order to engage the automatic mode, rather than pressing the button an unknown number of times, he may be more likely to find the device easier to use, and more capable of controlling the device using this feature. He would also be more likely to engage in Kill-A-Watt behaviors by turning off the lights when they leave the room.

H1f: User control will be positively related to participation in Kill-A-Watt behaviors.

User Knowledge and Control

Similar to perceived ease of use, research also suggests that the ability to effectively control the amenity is related to their understanding of the amenity's features.

H1g: User knowledge will be positively related to control.

User Ease of Use and Control

Prior research has demonstrated that when an individual experiences a sense of control over a device, he or she will also be more likely to feel that it is easier to use.

H1h: User ease will be positively related to control.

Understanding Regarding the Importance of Climate Change

Up until this point, I have been discussing how users interact with the devices in their rooms purely to meet their basic lighting, temperature, and device-powering needs. Regardless of whether or not a student is intentionally choosing to engage in these behaviors to save energy and be green, these are interactions that will occur in their rooms on a regular basis. However, it is important to consider the impact of their understanding regarding the importance of engaging in these behaviors from an intentional standpoint. If he or she is going to choose to specifically engage in these behaviors, they will be driven by a variety of attitudinal factors ranging from general environmental orientation to attitudes towards the specific PEB, with specific attitudes typically serving as a stronger indicator than general attitudes (Oskamp et al., 1991.) Findings from past research have “supported the idea that environmental beliefs significantly influence behavior when beliefs and behaviors are assessed at the corresponding level of specificity.” (Corral-Verdugo, Bechtel, & Fraijo-Sing, p. 255, 2003.) Since I am measuring attitudes toward Kill-A-Watt behaviors, which are a subset of energy saving behaviors that occur on UCF’s campus, there are several levels of specificity that can be identified for these behaviors as a type of PEB. Thus, for the scope of this dissertation, I focus on their understanding regarding the importance of engaging in these behaviors from varying degrees of specificity from the macro-level (the importance of climate change and its potential consequences for inhabitants of the Earth) to the micro-level (the influence of Kill-A-Watt on saving energy at UCF)

Research has indicated that subjective knowledge can actually be more influential in the carrying out of pro-environmental behaviors than objective knowledge (Ellen, 1994).

Specifically, knowledge that a pro-environmental behavior “is” important, rather than “how” it makes a difference, is related to sustainability behaviors. For example, users do not necessarily need to know the complex system dynamics associated with carbon emissions and climate change. Rather, it is enough to know that decreasing one’s energy use can positively impact the environment. So it is less important that they demonstrate a level of competency regarding exactly how individual behaviors influence greenhouse gas emissions, than it is that they simply state that they have an understanding regarding why these behaviors are important.

Given the above, findings suggest that knowledge about the positive impact of sustainability-related opportunities is a good predictor of on-campus behaviors (Levine & Strube, 2012). In this case, information may be provided from a variety of sources (e.g., resident advisors in student housing, signage around campus, emails, and outreach efforts associated with sustainability-related student organizations on campus). An individual’s level of understanding regarding the importance of these behaviors may influence their engagement, both through their use of the devices as well as through increased information seeking to improve their knowledge and meet their goals of engaging in these behaviors through enhanced interactions with these devices.

H2: Understanding regarding the importance of climate change will be positively related to Kill-A-Watt behaviors

Combined Influence of Built Environment and Environmental Attitudes

The hypotheses described thus far have focused largely on confirming the results from previous research, such as the influence of understanding regarding the importance of climate change, and exploring the impact of and relationships between factors such as user understanding, ease of use, and control. However, there is a lack of research that is focused on the *combined* influence of declarative and subjective understanding together with the factors within the built environment, which I argue will increase the overall predictive impact of these components.

H3: Factors of the built environment and understanding regarding the importance of climate change will demonstrate the strongest predictive ability of Kill-A-Watt behaviors when considered together.

Campaign Influence

Campaign Awareness

Regardless of how the individuals were interacting with their built environment previously, and whether or not they were engaging in behaviors relevant to the Competition, the awareness of Kill-A-Watt provides a significantly different driving force behind these interactions and behaviors. An awareness of the Competition now presents an intentional choice regarding whether or not to engage in these behaviors and a rationale for doing so. In this way, Kill-A-Watt influences behaviors by providing an increased understanding regarding the importance of engaging in these behaviors; regardless of what the student takes away from the

advertisements, be it the scholarship prize incentive or figures regarding energy saved in previous years, they must have some reason for wanting to participate. If they are somehow aware of the Competition, but not the reasons to take part, it will not likely influence their behaviors.

Participation in Kill-A-Watt Competition

Finally, the choice to participate in the Kill-A-Watt Competition represents an intentional choice to direct the relevant behaviors, with the added consideration of campaign awareness, toward actual, reported campaign participation, rather than PEB for any other reason.

H4: Awareness of the Kill-A-Watt Competition will be positively related to Kill-A-Watt behaviors.

In sum, the current study is designed to increase our understanding of how user factors interact with the built environment to affect behaviors associated with environmental sustainability. This includes assessments of various types of knowledge, comfort, and control, as they are associated with amenities in their dormitories. It also includes assessment of their knowledge about pro-environmental behaviors as well as their awareness of a campus campaign devised to promote sustainable behaviors. My goal is to redress a gap in HF/E research through integration of concepts from psychology and engineering and design to examine their interrelations with the built environment.

CHAPTER THREE: METHOD AND MATERIALS

Study Development

In order to design a study that would effectively explore the hypotheses listed in the previous section, I conducted field research across a number of departments on campus. First, since this work would test the existing methods used for the Kill-A-Watt Competition, I reviewed the campaign structure, outreach strategies, participation outcomes, and relevant areas of study with the previous student outreach coordinator, utility coordinator, and director of UCF's Office of Sustainability. I also met with the executive and associate directors of UCF's Department of Housing and Residence Life to discuss the goals of the research, logistics and support that would be involved, and their collaborative role.

Once I received approval from both departments to move forward and explore these areas of research within the framework of on-campus initiatives, I coordinated and met regularly with a Housing Sustainability Committee, consisting of graduate-level area coordinators and undergraduate resident advisors from the Department of Housing and Residence Life, as well as the Student Government Association's Health and Sustainability Coordinator. This committee provided insight regarding the internal processes for resident outreach, campaign management, incentives, and adoption, user behaviors (through the stipulations of their employed positions, all members resided on campus). Through this partnership, I was given the opportunity to speak at dozens of meetings spanning the hierarchy of departmental personnel and residents from which I gained further information and direction for the research, including, but not limited to: executive-

level meetings, housing-community-level meetings, Residence Hall Association meetings, regular hall meetings, and the Resident Leadership Institute.

I also coordinated with the superintendent of Facilities for Housing in order to determine the available amenities, the features provided for these devices, and general user capabilities with each of the variety of dormitory types on campus. Together with the superintendent and several members of the facilities, maintenance, and housing staff, I also conducted several walk-throughs of the housing communities to gain a better understanding of the space types, amenities, and typical resident questions, problems, and requests.

Each of these collaborations served to directly inform the survey development and study design, as detailed in the following section. Once the research plan and surveys were devised, these materials received further review and feedback from several technicians, engineers, and utility staff members, as well as the aforementioned partners in the Sustainability and Housing departments before finalization.

In order to deploy the study and determine the final incentives for participation (relative to department guidelines and competition with other initiatives), I collaborated with the assistant director of marketing in Housing to create the email and other publicity and notification materials and guidelines that would be used in conjunction with the Kill-A-Watt Competition outreach.

Participants

All students residing in on-campus housing were eligible to participate in the study. Participants were recruited in two ways. First, participants were recruited through an email that

was sent out to all on-campus residents on behalf of UCF's Department of Housing and Residence Life which contained an invitation to participate in the two-part study and included a direct link to the study in the website Qualtrics. In addition to providing participants with the opportunity to submit feedback about the university's largest sustainability campaign and thereby strengthen the school's mission of environmental stewardship, participants recruited through this method would also receive a \$5 cash payment as an incentive following the completion of the second survey.

The second method of recruitment was through the Psychology Department's research participation database, SONA Systems, in which students taking psychology courses that require participation for course credit can find, select, and sign up for the studies of their choice. As such, the incentive for participation was the fulfillment of some portion of required research course credits. According to SONA guidelines, students were eligible to receive 0.5 research course credits for each hour of participation in online studies. Therefore, since each survey took approximately 30 minutes to complete and participants were required to complete both sections of the survey (the first in February and the second in April), they received 0.5 research course credits for the combined 60-minute completion time. If the actual completion time was less, participants still received the full credit, per SONA guidelines. If the completion time took longer, they would be credited appropriately (0.25 credits per 30 minutes of participation).

Together, these two forms of recruitment drew an initial sample of 456 responses from the total 6,461 students who resided on campus. However, the final sample size was reduced to 240 participants due to attrition throughout the course of the study, as well as exclusion through

a variety of screening measures. For example, students were only allowed to take the survey once and receive the compensation that corresponded to their reported method of recruitment (cash payment for Housing-recruited participants or course credit for SONA-recruited participants). Precautions were taken to prevent and verify the possibility of participants completing or attempting to complete the survey more than once, as well as address a variety of other possible concerns. These procedures are described in further detail in the data screening portion of the Results section.

Procedure

A multiphasic within-subjects questionnaire was administered online, through a link in the Housing email and SONA webpage that led directly to the survey website Qualtrics. The first survey was administered in February 2015, before the start of the Kill-A-Watt Competition. The questions in this survey pertained to general background information (such as biodata and information about their dorm and housing community), level of knowledge regarding how to use their amenities, perception regarding ease of using these amenities, perceived control over these amenities, level of awareness of and participation in past campaigns, whether they sought out additional information regarding how to use their amenities and their motivation for doing so, and knowledge regarding the importance of PEB. The same survey link was provided to participants who were recruited through the email sent from Housing and those who signed up through SONA Systems.

Before beginning the survey, participants were asked to select the method by which they were recruited (either through Housing or SONA) and, correspondingly, provided with the

appropriate informed consent page that detailed the purpose and the timeframe of the study, the surveys to be completed, and the relevant form of compensation. It also stated that they needed to complete both surveys before receiving their reward, and verified that they had to live on campus and be at least 18 years of age or older to participate. At the bottom of this informed consent page, participants had to select whether they did 'accept' or 'do not accept' these conditions. If they accepted the conditions of the study, they were directed to begin the study. If they did not accept, they were thanked for their time, informed that they would not receive any compensation and were provided with the researcher's and faculty advisor's contact information. Once the participants began the first study in Qualtrics, they were assigned a random numerical identification code which was emailed to participants following the completion of the first survey.

The second survey was administered in April 2015, at the end of the Kill-A-Watt Competition. This survey focused on whether or not they were aware of and participated in the competition, and the degree to which changes occurred across these dimensions throughout the course of the competition. Participants were sent an email with their Qualtrics code and a link to the second survey, and were given two weeks to complete the survey. At the end of the study, the Qualtrics codes (belonging to participants who participated in both surveys) were used to provide course credit to the participants recruited through SONA and also to notify participants recruited through Housing to visit UCF's Office of Sustainability and claim their cash reward by providing their codes.

Surveys

February Surveys (see Appendix A)

The surveys administered in February included the following: Biodata, Amenities Within the Built Environment, Kill-A-Watt Behaviors, Perception of Knowledge, Ease of Use, and Control With Amenities Within the Built Environment, Knowledge Regarding How to Use Amenities Within the Built Environment, Awareness of Kill-A-Watt, Participation in Kill-A-Watt, and Seeking Out Knowledge, and Understanding Regarding the Importance of Climate Change.

Biodata

The first section contained background questions, such as age and sex, as well as questions regarding the participant's housing community and building, his or her type of residence (e.g. private dorm, shared apartment, number of bedrooms/bathrooms, etc.), and how long they had lived there.

Amenities Within the Built Environment

The amenities within the built environment survey contained questions regarding the degree of adjustability across the amenities available to each participant. The items in this survey were discerned from the field research investigation of the variety of options that were available within UCF's dormitories and accounts of user interactions with them. For the purposes of focusing on the energy-saving behaviors suggested by the Kill-A-Watt Competition, such as

turning off lights and increasing the temperature setting on the air conditioner, items included whether or not the dorm room had motion-sensor lighting in their hall or shared area, bathroom, and bedroom, whether there was an option to control these lights manually, a thermostat that could be adjusted, and whether there was a limited range of temperatures that could be adjusted. Another behavior encouraged in the Kill-A-Watt Competition was to unplug electronic devices, but there was no comparable survey item for this action, since the devices associated with it were power outlets, with several of which each dorm room was equipped.

Kill-A-Watt Behaviors

This survey included items regarding the degree to which the participant was already engaging in Kill-A-Watt-related behaviors, such as whether he or she regularly turned off lights, turned up the thermostat, and unplugged devices, measured on a six-point Likert scale from 1 (*completely disagree*) to 6 (*completely agree*).

Perception of Knowledge, Ease of Use, and Control with Amenities within the Built Environment

In this section, participants were asked to respond with their subjective level of procedural understanding regarding how to control each of the relevant devices (lighting, thermostat, and power outlets), the degree to which they found these devices easy to use, and the degree to which they were happy with their ability to control these devices, measured on a six-point Likert scale from 1 (*completely disagree*) to 6 (*completely agree*).

Knowledge Regarding How to Use Amenities within the Built Environment

This survey used objective knowledge questions to assess the participant's level of procedural knowledge regarding how to use their lighting, thermostat, and power outlets. For each question, two possible answers were provided; one that was correct and one that was incorrect. For example, participants completed the following sentence "I conserve more when I..." by selecting the correct response between "Unplug electrical devices when not in use" or "Leave them plugged in, but turn them off".

Awareness of Kill-A-Watt

This section contained questions regarding the participants' level of awareness with past Kill-A-Watt Competitions, as well as with the upcoming competition in the then-current spring semester, measured on a six-point Likert scale from 1 (*completely unaware*) to 6 (*completely aware*).

Participation in Kill-A-Watt

This scale contained questions regarding whether the respondents participated in prior Kill-A-Watt Competitions by saving energy and/or submitting an essay. Additionally, participants were asked whether they planned to participate in the upcoming competition in that current spring semester by responding "yes" or "no".

Seeking Out Knowledge

Items in this section focused on whether the participant sought out information regarding how to use the amenities in their dorm room (by responding "yes" or "no"), and their motivation

for doing so, such as to simply make it easier to use the amenities or to take part in the Kill-A-Watt Competition, measured on a six-point Likert scale from 1 (*completely disagree*) to 6 (*completely agree*).

Understanding Regarding the Importance of Climate Change

This scale contained subjective knowledge items regarding the degree to which the participant felt knowledgeable about the importance of climate change, behaviors that can impact climate change, saving energy in general, saving energy at UCF, and engaging in Kill-A-Watt behaviors, measured on a six-point Likert scale from 1 (*completely disagree*) to 6 (*completely agree*).

April Surveys (see Appendix B)

The second round of surveys included identical versions of the following surveys: Amenities Within the Built Environment, Kill-A-Watt Behaviors, Perception of Knowledge, Ease of Use, and Control With Amenities Within the Built Environment, Knowledge Regarding How to Use Amenities Within the Built Environment, and Understanding Regarding the Importance of Climate Change. It also included slightly altered versions of the Awareness of Kill-A-Watt, Participation in Kill-A-Watt, and Seeking Out Knowledge surveys.

Awareness of Kill-A-Watt

The second round of the Awareness survey focused on the degree to which participants were aware of the Kill-A-Watt Competition in the semester that had passed, measured on a six-point Likert scale from 1 (*completely unaware*) to 6 (*completely aware*).

Participation in Kill-A-Watt

The second Participation survey asked participants to indicate whether they participated in the Kill-A-Watt Competition by saving energy and writing an essay in the semester that had just passed by responding “yes” or “no”.

Seeking Out Knowledge

The second round of the Seeking Out Knowledge survey focused on whether the participant sought out additional information regarding how to use his or her amenities since the start of the semester (by responding “yes” or “no”) and the degree to which they sought this information to simply make it easier to use the amenities, to take part in energy-saving behaviors, or to take part in the Kill-A-Watt Competition in the semester that had just passed, measured on a six-point Likert scale from 1 (*completely disagree*) to 6 (*completely agree*).

CHAPTER FOUR: RESULTS

Data were analyzed using IBM SPSS Statistics 23 (IBM Corporation, 2015) and IBM SPSS AMOS 23 (IBM Corporation, 2015). I used an alpha level of .05 for all statistical tests.

Data Screening

In this section, I will describe the data screening technique used to identify incomplete or erroneous data, as well as participant attrition throughout the various stages of the study. Figure 1. is provided as a helpful visual aid to this process.

Duplicate Participation

A total of 456 participant codes was generated by Qualtrics for the first survey (T1). Since the incentives for participation included either a cash payment for participants recruited through the email sent out to all on-campus residents or course-required research participation credits for participants recruited through SONA systems, precautions were taken to prevent participants from completing the survey more than once. In study scenarios in which participants are recruited by individual invitation, it may be preferable to provide a unique survey link to each participant. However, since the form of recruitment was a mass email to on-campus residents and a single link that could be accessed through SONA Systems, another approach that applied to a study with a single survey link was required. As such, the study was designed in Qualtrics to recognize when the same user attempted to use the link to reopen the survey after completion, to then block access to the survey, and provide an error message stating that each participant may only complete the survey once. However, due to the current limitations in

Qualtrics capabilities, participants could access and reopen the survey after clearing out the cookies on their web browser, by using a different web browser, or a different device. In order to address this concern, students were required to provide their UCF Knights email address, of which students are only allowed to have one registered account (rather than some other type of email account, such as Gmail) for study correspondence. Although all attempts were made to maintain the maximum level of confidentiality for participants, in accordance with UCF's Institutional Review Board (IRB) protocol, these email addresses were matched to Qualtrics ID codes only, and never participant data. Furthermore, since only two email addresses were listed more than once in the participant list, this matching procedure was performed twice. Both participants independently confirmed via email that they did not receive a confirmation email after their first survey attempt and that they had completed the survey twice in order to ensure that their participation was recorded. In both cases, Qualtrics IDs and data from the first attempt only were included in subsequent analyses. With these two duplicates removed from the data set, 454 Qualtrics IDs remained.

Within this sample, it was determined that two of the participant codes had been generated by Qualtrics, without any responses to the informed consent page (or any other data points throughout the study), leaving 452 ID codes. However, due to the web-based nature of the survey, there is a chance that participants may have opened a survey link in a browser window, viewed the beginning of the survey, and either chose not to continue, and/or accidentally exited the browser window. Since the survey would not have been recorded as 'complete' in these instances, these participants would still be able to use the link to access and restart the survey,

but a new Qualtrics ID code would be generated upon each attempt. As discussed above, there were only two cases of duplicate email addresses and two additional participants whose ID codes by Qualtrics were generated without any responses. Therefore, the remaining sample at this stage may include incidences of exiting and restarting the survey, but these responses must have occurred just after the consent page, but prior to entering an email address or responding to any survey items.

Participant Attrition

Attrition at the Consent Stage

Based upon the data from the consent page, 356 responses indicated recruitment through email, with 354 agreements to the terms of the study and two declines. Ninety-six responses indicated recruitment through SONA, with 93 agreements to the terms of the study and three declines. Together, there were 447 responses at this stage, including possible duplicates who dropped out before responding past the consent page.

Attrition During T1

Upon agreement to the terms of the study, participants were directed to enter and confirm their UCF Knights email address and are provided with their ID codes before they can advance to the first set of questions for the survey. Between the consent page and the actual responses, 398 participants (314 from email and 84 from SONA) continued on to the actual survey items, while 54 (42 from email and 12 from SONA) were either participants who returned to provide their email address and start the survey at a later time or who quit the study at that time. Since there is

no data for these individuals, there is no way to confirm whether they returned to complete the study or dropped entirely, but there is also no risk to the survey data since they provided no responses.

Completion of T1

Between the start and the end of the T1 survey, 385 participants (306 from email and 79 from SONA) completed all of the survey items. However, 13 participants (eight from email and five from SONA) quit the survey before completing all of the items for T1.

Attrition between T1 and T2

After sending participants the email invitations to complete the second survey with their unique Qualtrics ID codes, 262 participants (223 from email and 39 from SONA), returned to the survey and began T2. In contrast, 157 participants (83 from email and 40 from SONA) did not return.

Completion of T2

From those who returned to T2, only two participants (from email recruitment) quit the study before completion, leaving a final completion sample of 260 participants (221 from email and 39 from SONA).

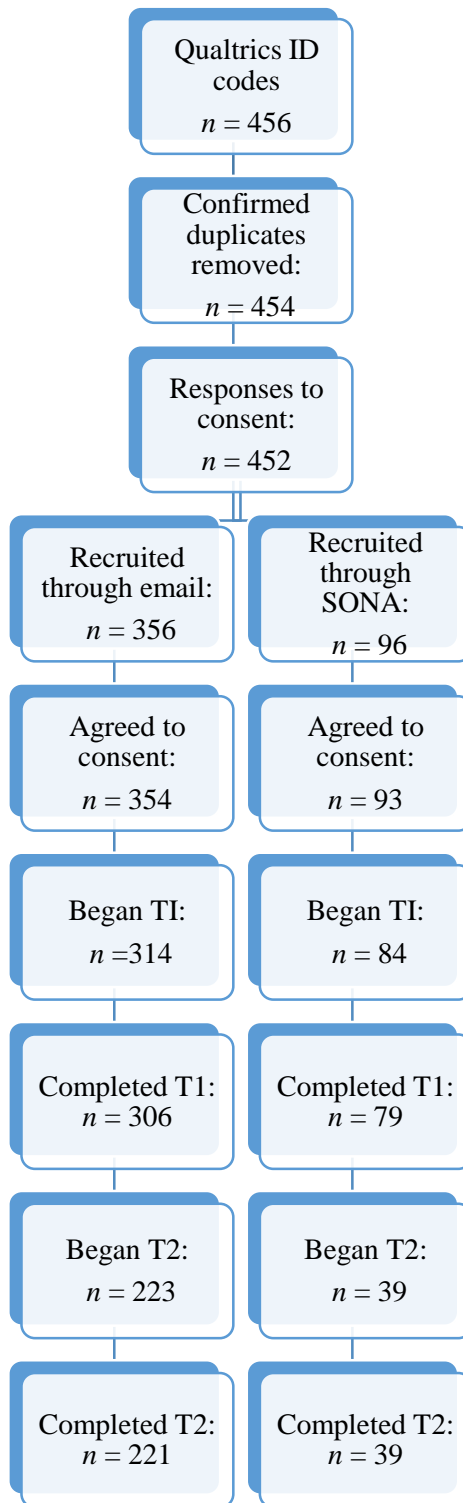


Figure 1: Participant attrition

Analyses for Selective Attrition

A series of preliminary analyses were run in order to determine whether there were systematic differences between those who started, but did not complete T1, participated in T1 only and those who returned to complete T2 (see Figure 1).

Chi-square analyses on sex, race, ethnicity, class standing, and housing community, and independent samples t-tests on age did not identify any significant differences between these groups in terms of T1 or T2 completion.

Chi-square analyses revealed that SONA participants were significantly less likely to return to the second survey than those recruited by email. A possible reason for this difference in retention rate is due to the time frame and nature of the incentives; housing participants were encouraged to participate to obtain a cash prize with no expiration date, whereas SONA participants participated to acquire course credit, which may have been due prior to the launch of the second survey and/or fulfilled by participation in other research by that point in the semester. However, a follow-up means comparison on gender, race, ethnicity, class standing, and housing community by recruitment method (email vs. SONA) did not reveal any significant differences in T2 participation across these groups.

Off-Campus Participation

Since only on-campus students were eligible to take part in the study, participants were asked to verify that they lived on campus when agreeing to the research conditions on the consent page before beginning the study. However, 28 participants listed off-campus housing complexes in their response to their residence hall name in the pre-survey, eight of whom went

on to complete T2. Possible explanations for their participation in spite of their ineligibility may include confusion of the term “on-campus” (many residences near UCF’s main campus or otherwise associated with the university use similar language) or incentive-driven participation, where participants knew they were ineligible but tried to participate to obtain the SONA credit (seven off-campus participants reported recruitment through SONA) or the cash payment (two remaining off-campus participants reported recruitment through email, suggesting that either some participants received the email despite living off-campus, had moved since Housing’s email records had been updated, or had received the forwarded email from someone who did live on campus). With these eight participants removed, a sample of 252 participants remained.

As an additional precaution against off-campus participation, participants’ responses regarding the number of bedrooms and bathrooms in their dormitory were compared to the actual floor plans available in that residence hall. Once again, a misinterpretation of terminology may have played a role, as participants may have considered a bathroom that is not shared with suitemates or an entire floor as a “private” bathroom, whereas other participants may only consider a bathroom that is used by a single individual as “private”, for example. Eleven participants (nine from email and two from SONA) provided responses that were inconsistent with their reported residence halls, leaving a sample of 241 participants remaining in the sample.

Duration of Participation

The time spent by participants on each survey was reviewed in order to identify surveys that were completed so quickly to suggest that participants may not have truly considered and thoughtfully responded to the questions. Given the length of the survey, I decided to remove

those participants, prior to any data analysis, who were below one standard deviation of the mean in completion time. The completion time for outliers with unusually long durations (50 minutes or longer in T1 or 40 minutes or longer in T2, $n = 12$ in both cases) were removed from this analysis in order to determine the most accurate means and standard deviations for surveys that were completed in a single sitting, rather than over the course of some extended time (as suggested by these longer times). The mean completion time for T1 was 10.30 minutes with a standard deviation of 6.63 minutes. An investigation of the distribution for participation duration in T1 revealed that the seven participants who completed the survey in less than four minutes had already been removed from the sample prior to analysis due to the several screening measures described above. Since the mean completion time for the T2 was 6.60 minutes with a standard deviation of 4.88 minutes, a single participant who completed the survey in two minutes was removed from the sample prior to analysis, leaving a final sample of 240 participants.

Participant Demographics

The participants remaining in the final sample ranged in age from 18 to 29, with a mean age of 19.18 ($SD = 1.56$). In terms of class standing, 64.6% (155) were freshmen, 20% (49) were sophomores, 9% (21) were juniors, 6% (14) were seniors, and 0.4% (1) were graduate students. Females comprised 73% (175) of the sample, males were 25% (61), and 2% (4) preferred not to answer regarding gender. The majority of the sample, 76% (182) identified as Caucasian, 16% (39) identified as Black, 13% (30) identified as Asian, 0.4% (1) identified as American Indian, and 0.4% (1) identified as Native Hawaiian or Pacific Islander. Across the sample, 18% (44) identified as Hispanic or Latino.

Study participants included residents of each of UCF’s seven housing communities and represented 3.7% of the total population of on-campus residents. As shown in Table 1, the distribution of participants across the current study was generally reflective of the number of residents in each community relative to the total on-campus population.

Table 1 Housing Community Representation and Participation Rate in Current Study

Housing community	Total number of residents (<i>N</i>)	Representation of on-campus population (%)	Number of study participants (<i>n</i>)	Representation of study sample (%)	Community participation rate (%)
Nike	820	12.7	29	12.1	3.5
Hercules	820	12.7	39	16.3	4.8
Libra	990	15.3	45	18.8	4.5
Lake Claire	720	11.1	29	12.1	4.0
Towers	2036	31.5	51	21.3	2.5
Apollo	420	6.5	20	8.3	4.8
Neptune	655	10.1	27	11.3	4.1
Total	6461	100	240	100	3.7

The period of time that participants had lived in their current dormitory ranged from one to 18 months, with a mean of 5.77 months ($SD = 1.71$). These results show that the majority of participants, 88% (211), moved into their respective dormitory during the August move-in period for the 2014 fall semester, six months prior to T1 and the start of the competition. The remaining 29 participants moved into their dorms one month prior, during the January move-in period for the 2015 spring semester, 5% (13); eight months prior, during the June move-in period for the 2014 summer semester, 2% (5); moving at some other point between the prior two- to five-

month period, 4% (9); or during the August move-in period for the previous academic year, 2013 fall semester, 1% (2).

Analyses

Scores Reported Across Measurement Scales

The majority of measurement scales employed in this study included items regarding attitudes toward and behaviors involving several different devices (lighting controls in different rooms, thermostat controls, and power outlets in different rooms), and therefore provided utility at both the individual item or device level, as well as general totals or averages for a specified domain of attitudes or behaviors for a given participant. Several scores are reported at the aggregate or average level and the reported scores are detailed below.

Individual Item Scores

Scores for the Biodata, Seeking Out Knowledge, Awareness of Kill-A-Watt Competition, and Participation in the Kill-A-Watt Competition scales are reported at the individual item level.

Aggregate Scores

A total score was calculated to present an overall depiction of the level of adjustability available for the amenities present in each dorm room. This score ranged from 1-7 and was derived from the following calculation: One point each for lights in each room (hallway/shared area, bedroom, and bathroom) that are manually controlled or are motion-sensor-activated, but include a manual control option; one point for an adjustable thermostat and one additional point if this thermostat does not have a limited range of temperature options; one point for reported satisfaction

regarding the number of power outlets available and one point for reported satisfaction regarding the location of power outlets available.

Average Scores

The averages were reported for the following scales: Interaction With Amenities Within the Built Environment, Perception of Knowledge, Ease of Use, and Control With Amenities Within the Built Environment.

Internal Consistency

The two remaining scales, Objective Knowledge Regarding How to Use Amenities Within the Built Environment and Understanding Regarding the Importance of Climate Change, each utilized a variety of items to depict a single overarching factor, energy literacy and self-reported climate change literacy, respectively. As such, Cronbach's alpha was calculated for these two scales in order to determine their internal reliability.

Understanding Regarding the Importance of Climate Change

The Understanding Regarding the Importance of Climate Change scale that I created for this study had very good internal consistency, with Cronbach's alpha coefficient reported of .90 in T1 and .96 in T2. Participant scores indicated that a reported understanding regarding climate change at the broadest, most macro level (e.g. "I understand why climate change is important for the Earth and all of its inhabitants") was highly consistent with a reported understanding regarding climate change at a much more specific, micro level ("I understand why it's important

to engage in Kill-A-Watt related behaviors”). As such, an average score is reported for overall understanding regarding the importance of climate change.

Knowledge Regarding How to Use Amenities

The Knowledge Regarding How to Use Amenities scale that I also created for this study demonstrated low internal consistency, yielding a Cronbach alpha coefficient of .21 in T1 and .36 in T2. The corrected item-total correlation for each survey item was below .3 for all items in both T1 and T2 and the removal of any single item failed to result in a Cronbach’s alpha above a .4 in either T1 or T2. Instead, scores on each individual item depicted a component of energy literacy that was unique and independent of the other items (i.e. a correct score regarding understanding when motion sensor lights turn off was unrelated to the accuracy of a score regarding how to save the most energy when using a power strip).

Hypothesis Testing

This research sought to address the gap between disparate areas of study regarding factors that influence pro-environmental behaviors within a given built environment. Past social science research has heavily focused on the impact of environmental attitudes on pro-environmental behavior engagement. More recent research within the fields of engineering and human factors has investigated the impact of the design of the built environment on these behaviors, although this work is still largely in its infancy. Limited research on human interaction with the built environment has identified the importance of the user experience of interacting with the built environment in terms of knowledge, ease of use, and control, on pro-

environmental outcomes. Finally, social science work has examined the influence of environmental campaigns on these behaviors. However, little is known regarding the *combined* impact of built environment factors together with environmental attitudes on pro-environmental behaviors or the degree to which an environmental campaign may differentially influence these routes towards behavior change when considered simultaneously.

In this section of the results, I present the findings from the analyses conducted to test the four sets of hypotheses designed to explore the separate influence of each of these areas of interest on energy-saving behaviors within the context of on-campus dormitories at the University of Central Florida over the course of a two-month energy reduction campaign: the degree to which factors within the built environment affect energy-saving behaviors (and the interrelationships among these factors), the effect of environmental attitudes on these behaviors, the combined impact of both built environment factors and environmental attitudes on energy-saving behaviors, and the degree to which the Kill-A-Watt Competition influenced behaviors through either positively benefitting interactions within the built environment, increasing pro-environmental attitudes, or both. The descriptive statistics for each of these variables are listed in Table 2.

Built Environment

Past research has suggested that building users are likely to engage in energy-conserving behaviors if they: (a) have access to amenities that can be controlled; (b) they understand how to use the amenities or figure out how to use them; (c) they find the amenities easy to use; and (d)

they have a sense of control over the amenity. Furthermore, these factors will be interrelated and demonstrate several relationships between them.

Amenities on Behaviors

When an individual is attempting to conduct day-to-day energy-related behaviors in his or her built environment, such as turning on the lights when they enter a room, this task will, by definition, be driven by a desire to change the current state of the built environment (luminance, temperature, etc.), regardless of whether or not this change is related to energy conservation. As mentioned earlier in this paper, research suggests that satisfaction with the process of interacting with the amenities is often more important than the actual outcome state, which is highly subjective, transient, and influenced by a variety of cultural, personal, and informational factors. Thus, it is less important to focus on whether or not the user is comfortable with the resulting level of lighting, temperature, etc., and more important to ask whether they were comfortable with the *process* of interacting with their amenities. In order to interact with the built environment and effect any degree of change, a user will need an energy-related amenity that offers some degree of control.

H1a: The availability of adjustable amenities will be positively related to participation in Kill-A-Watt behaviors.

Amenity adjustability was significantly correlated with Kill-A-Watt behaviors ($r = .26, p < .001$), as displayed in Table 3, and was also the strongest single predictor of these behaviors at

T2 (adjusted $R^2=.062$, $F(1, 238) = 16.77$, $p < .001$). Specifically, participants' predicted Kill-A-Watt behaviors were equal to 2.843 (average frequency of behaviors, where a score of '1' is 'never' and '6' is 'always') + 0.194 for each degree of adjustability across the amenity total (0-7, based upon the sum of adjustable options provided by the lights, thermostat, and power outlets, as described earlier in the Results section). These results are displayed in Table 4, shown together with a series of single regressions completed to test the influence of each variable on Kill-A-Watt behaviors at T2. Preliminary analyses were conducted to ensure there were no violations of the assumptions of normality, linearity, multicollinearity, and homoscedasticity for each regression analysis reported in this Results section.

Table 2 Descriptive Statistics for Each Variable Reported at T1 and Kill-A-Watt Behaviors Reported at T2

	<i>M</i>	<i>SD</i>	Skew	Kurt
Amenity adjustability	5.35	1.19	-1.31	1.17
Subjective understanding	5.41	0.84	-1.89	4.43
Objective knowledge	0.79	0.17	-0.67	0.27
Information seeking	0.12	0.33	2.34	3.51
Ease of use	5.38	0.81	-1.88	4.55
Sense of control	4.89	1.06	-1.15	1.33
Climate change understanding	5.44	0.86	1.85	3.70
Kill-A-Watt behaviors	3.88	0.90	-0.23	0.43

Note. Total amenity scores ranged from 1-7, based on the total number of adjustable options across all devices. Average scores for reported user understanding, ease of use, and control across all devices, and understanding regarding climate change range from 1 (*completely disagree*) to 6 (*completely agree*). Scores for objective knowledge were based on the average number of correct responses to a series of true/false items regarding energy literacy. Information seeking responses ranged from 1 (*no*) to 2 (*yes*). Scores for Kill-A-Watt behaviors ranged from 1 (*never*) to 6 (*always*).

* = $p < .05$, ** = $p < .001$.

Table 3 Bivariate Correlations Across Each Variable Reported at T1 and Kill-A-Watt Behaviors Reported at T2

	1	2	3	4	5	6	7
Amenity adjustability							
Subjective understanding	.26**						
Objective knowledge	-.01	-.01					
Information seeking	.032	.07	-.14*				
Ease of use	.37**	.78**	-.04	.07			
Sense of control	.41**	.48**	-.03	.06	.64**		
Climate change understanding	.15*	.40**	.09	.06	.38**	.26**	
Kill-A-Watt behaviors	.26**	.22**	.01	.04	.23**	.19**	.21**

Note. As discussed in the previous section, Scores Reported Across Measurement Scales, several of the variables included in this table are derived from scales with varying measurement properties for which a single measure of reliability or disattenuation correction cannot accurately assess.

* = $p < .05$, ** = $p < .001$.

Table 4 Single Regression for the Individual Influence of Each Variable at T1 on Reported Kill-A-Watt Behaviors Reported at T2

Variable	<i>b</i>	<i>SE</i>	B	<i>t</i>	<i>F</i>	Adjusted <i>R</i> ²
(Constant)	2.843	.260		10.939		
Amenity adjustability	0.194	.047	.257	4.096	16.77**	.062
(Constant)	2.591	.370		6.995		
Subjective understanding	0.239	.068	.223	3.527	12.44*	.046
(Constant)	3.846	.272		14.164		
Objective knowledge	0.047	.335	.009	.140	.019	-.004
(Constant)	3.869	.062		62.095		
Information seeking	0.110	.179	.040	.614	.377	-.003
(Constant)	2.525	.384		6.573		
Ease of use	0.252	.071	.226	3.575	12.78**	.047
(Constant)	3.104	.271		11.438		
Sense of control	0.159	.054	.187	2.935	8.62*	.031
(Constant)	2.676	.365		7.323		
Climate change understanding	0.222	.066	.212	3.345	11.19*	.041
(Constant)	3.812	.100		38.001		
Awareness of Kill-A-Watt	0.043	.050	.056	.861	.742	-.001

Note. Total amenity scores ranged from 1-7, based on the total number of adjustable options across all devices. Average scores for reported user understanding, ease of use, and control across all devices, and understanding regarding climate change range from 1 (*completely disagree*) to 6 (*completely agree*). Scores for objective knowledge were based on the average number of correct responses to a series of true/false items regarding energy literacy. Information seeking responses ranged from 1 (*no*) to 2 (*yes*). Awareness of Kill-A-Watt responses ranged from 1 (*completely unaware*) to 6 (*completely aware*).
 * = $p < .005$; ** = $p < .001$

User Knowledge

Next, a user choosing to interact with their built environment to change the state of an energy-using device, will require an understanding regarding how to use the amenity, which is determined by both the particular amenity in question, as well as their understanding for that particular device. Although, there is limited research on this influence and no standardized

metrics for measuring it, the existing research suggests that perceived understanding is an important component for predicting and influencing energy-related behaviors. The relationship between objective user knowledge and behaviors is less clear.

H1b: User knowledge regarding how to use an amenity will be positively related to participation in Kill-A-Watt behaviors.

Subjective user understanding was both significantly correlated with Kill-A-Watt behaviors at T2 ($r = .22, p < .005$) and one of the strongest predictor of these behaviors (adjusted $R^2 = .046, F(1, 238) = 12.44, p < .001$), with participants' predicted Kill-A-Watt behaviors equal to 2.591 (average frequency of behaviors) + 0.239 for each degree of user understanding, as measured as an average score for reported understanding across amenities. However, objective knowledge was neither significantly correlated with, or a significant predictor of, Kill-A-Watt behaviors.

Seeking Out Information

When the user may not have adequate knowledge regarding how to operate a device, he or she may seek out additional information for its use. There is particularly limited research regarding how individuals may obtain information about their amenities if the instructional information provided to them was insufficient or nonexistent

H1c: Information seeking behaviors will be positively related to user knowledge.

A small number of participants reported seeking information regarding how to use their amenities for any purpose ($n = 29$ at T1; $n = 24$ at T2). These behaviors had small negative correlation with objective knowledge. However, these behaviors were neither significantly correlated with, or a significant predictor of, Kill-A-Watt behaviors.

User Ease of Use

Research has consistently demonstrated that a user's perception of ease with using the device will influence whether he or she chooses to use or avoid it. Although perceived ease does not directly affect their actual ability to effectively control an amenity, it will influence it to an extent; one can still control a device that is difficult to use, but will be less likely to use it or make adjustments regularly.

H1d: User perception regarding ease of using the amenity will be positively related to Kill-A-Watt behaviors.

Ease of use shared a significant positive correlation with Kill-A-Watt behaviors ($r = .23$, $p < .001$) and influence on them (adjusted $R^2 = .047$, $F(1, 238) = 12.78$, $p < .001$), with predicted values at $2.525 + 0.252$ for each degree of perceived ease across amenities, that was nearly comparable to the predictive influence of subjective user understanding.

User Knowledge and Ease of Use

Past research findings also suggest that a user's understanding regarding her ability to use a device influences her perception of ease with using it; if a user knows how to use a device, they will often find it easy to use, whereas a user who doesn't know how to use the device's features will find the same tasks difficult.

H1e: User knowledge will be positively related to ease of use.

User ease of use was positively correlated with subjective user understanding ($r = .78, p < .001$) at T1, but was not significantly correlated with objective knowledge.

User Control

Research suggests that individuals are significantly more satisfied with their environment when they have more control over it – even when the outcome state would not otherwise seem satisfactory to them. As such, users will be more likely to engage in conservation behaviors if they feel that they have the control to influence the devices required to take part in these behaviors.

H1f: User control will be positively related to participation in Kill-A-Watt behaviors.

User control was correlated with Kill-A-Watt behaviors ($r = .22, p < .005$) and significantly predicted these behaviors, although to a lesser extent than user understanding or ease of use, ($R^2 = .031, F(1, 238) = 8.62, p < .005$) equal to $3.104 + 0.159$ for each degree of perceived control across amenities.

User Knowledge and Control

Similar to perceived ease of use, the ability to effectively control the amenity is related to their understanding of the amenity and the actual amenity's features.

H1g: User knowledge will be positively related to control.

Subjective user understanding was significantly correlated with user perception of control at T1 ($r = .48, p < .001$)

User Ease of Use and Control

Prior research has demonstrated that ease of use is related to control. Specifically, if a user finds a device easy to use, they will likely experience an improved sense of control over it.

H1h: User ease will be positively related to control.

The user ease of use average reported at T1 was positively correlated with average control reported at T1 ($r = .64, p < .001$).

Environmental Attitudes

The desire to engage in energy-saving behaviors relies on some awareness of the opportunity and reason to reduce energy. As such, building users typically want to save energy for some distal environmental goal, based on their level of understanding regarding the importance of climate change, to obtain some incentive, such as winning a prize as part of the competition. Depending on the nature of this incentive-driven behavior, it may or may not influence their desire to save energy. Research has suggested that subjective understanding regarding why a behavior is important is more influential than actual objective knowledge regarding its importance. Put simply: Building users are likely to engage in conservation behaviors if they have an understanding regarding why it's important to do so.

H2: Understanding regarding the importance of climate change will be positively related to Kill-A-Watt behaviors.

Understanding regarding climate change was both related to ($r = .64, p < .001$) and a significant predictor of Kill-A-Watt behaviors at T2 (adjusted $R^2 = .041, F(1, 238) = 11.19, p <$

.005), with predicted Kill-A-Watt behaviors are equal to $2.676 + 0.222$ for each degree of understanding regarding understanding of climate change.

Combined Influence of the Built Environment and Environmental Attitudes

Thus far, the hypotheses and results discussed have focused largely on confirming and replicating the findings from previous research, such as the influence of attitudinal factors and general considerations regarding the built environment, and further exploring the relationships between factors such as user procedural understanding, ease of use, and control, that have not been studied as extensively. However, whereas energy conservation research has focused heavily on attitudinal and motivational factors, or, less often, on factors regarding the influence of the built environment, there is a notable lack of research explicitly focused on the *combined* influence of these design elements together with attitudinal factors.

When building users are asked to conserve energy through behaviors like turning off the lights when leaving a room, the necessary action is to change the current state of the built environment for the purpose of a goal that is separate from comfort. With this goal in mind, users now approach their amenities with a potentially different perspective than non-conservation behaviors with the same amenities (e.g. “I am choosing to turn off the light, not because of how this environmental state is affecting my comfort, but for the greater good of the planet.”). However, regardless of the goal, users will still be influenced by the same amenity-based factors as if they were using these devices for any other purpose. That is, these behaviors will still be affected by the level of adjustability offered by the amenity, as well as any difficulties presented

by a lack of knowledge, ease of use of control, even if the user approaches these devices with an intent to behave differently.

H3: Factors of the built environment and understanding regarding the importance of climate change will demonstrate the strongest predictive ability of Kill-A-Watt behaviors when considered together.

Each of the built environment factors and the average scores for understanding regarding climate change were entered into a regression model to assess the ability of these combined components to predict participation in Kill-A-Watt behaviors in T2. All variables were entered regardless of significance in the single regressions reported above. Amenity adjustability was entered into Model 1, explaining 6% of the variance in Kill-A-Watt behaviors (adjusted $R^2 = .062$, $F(1, 238) = 16.77$, $p < .001$). After understanding regarding climate change was entered into Model 2, the total variance explained by the model as a whole was 10% (adjusted $R^2 = .089$, $F(1, 237) = 12.71$, $p < .001$). Participants' understanding regarding climate change explained an additional 3% of the variance in Kill-A-Watt behaviors (Δ adjusted $R^2 = .031$, $\Delta F = 8.14$, $p = .005$). In the final model, displayed in Table 5, both two measures were statistically significant, with the amenity total score recording the highest beta value ($\beta = .23$, $p < .001$) than understanding regarding climate change ($\beta = .18$, $p < .010$).

Table 5 Forward Regression Results for the Combined Influence of Built Environment and Attitudinal Factors at T1 and Reported Kill-A-Watt Behaviors Reported at T2

Model		<i>b</i>	<i>SE</i>	β	<i>t</i>	<i>F</i>	Adj <i>R</i> ²	Adj ΔR^2
1	(Constant)	2.843	.260		10.939			
	Amenity adjustability	0.194	.047	.257	4.095	16.77**	.062	-
2	(Constant)	1.935	.409		4.734			
	Amenity adjustability	0.175	.047	.230	3.694			
	Climate change understanding	0.187	.065	.178	2.854	12.71**	.089	.027

Note. Total amenity scores ranged from 1-7, based on the total number of adjustable options across all devices. Average scores for reported understanding regarding climate change range from 1 (*completely disagree*) to 6 (*completely agree*).
 ** = $p < .001$

Campaign Awareness

The Kill-A-Watt Competition lasted for two months, from February through April of 2015, across all on-campus housing communities, was presented as an opportunity to take part in a competition with other housing buildings to save energy to help UCF to be more sustainable and to be rewarded with a scholarship prize. The “Kill-A-Watt” conservation behaviors that were suggested in campaign materials included: (a) unplug devices; (b) take shorter showers; (c) switch to CFL light bulbs; (d) turn up thermostat; (e) turn off lights; and (f) give computers a break. Residents of buildings who saved the most would be eligible (building-wide data) to submit an essay for scholarship consideration (5 each at \$100, \$350, and \$750, according to the quality of the essay).

Awareness for the competition was based on a housing-wide email, flyers posted in residence halls, tabling at housing communities and in UCF library, Sustainable UCF’s website

and Facebook page, and UCF Housing website and Facebook page, and word-of-mouth. For the purposes of this study, I specifically explored the degree to which campaign awareness was effective at influencing the behaviors encouraged in its promotional materials.

H4: Awareness of the Kill-A-Watt Competition will be positively related to Kill-A-Watt behaviors.

Awareness of the competition at T2 was related to Kill-A-Watt behaviors at T2 ($r = .21, p < .005$) and was a significant predictor (adjusted $R^2 = .039, F(1, 238) = 10.74, p < .005$) of these behaviors, with predicted Kill-A-Watt behaviors equal to $3.493 + .123$ when the level of awareness of the competition was measured on a six-point Likert scale from 1 (*completely unaware*) to 6 (*completely aware*).

Together, these findings demonstrated the influential roles of elements within the built environment, knowledge regarding the purpose of the behaviors, awareness of the campaign, and the actual behaviors encouraged therein. In the next section I discuss my interpretation of these findings individually, as well as taken together, and how this work provides a unique contribution towards the advancement of HF/E research and the field's impact towards sustainability.

CHAPTER FIVE: DISCUSSION

Study Findings

The Built Environment

First, the findings regarding the built environment demonstrated that amenity adjustability significantly predicted self-reported pro-environmental behaviors. These results support past research findings (Brown & Cole, 2009; Doulos, Tsangrassoulis, & Topalis, 2007; Levine & Strube, 2012) that have demonstrated that the degree to which a building user can interact with his or her environment may influence their actions as a result. That is, residents of dormitories with fewer opportunities to directly make adjustments to their environment were less likely do so, including engaging in actions suggested by the campaign, such as turning off lights or unplugging devices.

These results for amenity adjustability also show how building users interact differently with their environment depending on the devices available to them. This further suggests an avenue for future research that can study the influence of these devices on creation of behavior change, as will be discussed later in this chapter. For example, future research and theory may focus on developing a systematic understanding of the characteristics of adjustable options across devices in order to predict user behavior, and thus how to better target users based on the options available to them.

Second, despite being previously under-researched, self-reported procedural knowledge was shown to be one of the factors most strongly associated with self-reported sustainable behaviors. This finding demonstrates that user knowledge may be an important mechanism for

helping to guide effective interactions with energy saving devices. This result reflects the findings from the limited research in this area (e.g. Tuomey, 2009) and suggests that knowledge may serve as a gateway to utilizing the devices; with the knowledge regarding how to use an amenity, the user is more capable of utilizing the device for whatever purposes he or she desires; whether it is turning off the lights to save energy or because he or she is going to bed, for example. Furthermore, this finding highlights the importance from studying the built environment from a HF/E perspective with a focus on usability. Specifically, understanding how to use the device was also related to other perceptions of the built environment; users who reported a higher degree of understanding regarding how to use their devices also reported that they had more control over these devices and that they were easier to use. Thus, knowledge may not only unlock the opportunity for use, but also afford an easier, more successful process of controlling the device. As such, knowledge may be a relevant and appropriate factor for further exploration in the realm of usability theory.

As with prior research (Aertsens, Mondelaers, Verbeke, Buysse, & Van Huylenbroeck, 2011), the objective questions regarding user knowledge of the devices were not significant predictors of PEB, nor were these responses related to the other built environment factors, such as perceived ease or control, or subjective understanding regarding the importance of these behaviors in terms of influencing climate change. It seems that building users may be influenced by their confidence in their knowledge of operating particular devices, rather than knowledge regarding whether this interaction will successfully lead to increased energy savings. There are a few possible explanations for this incongruity. First, survey items pertaining to subjective

understanding specifically referred to whether the participants knew how to use their devices, regardless of whether this use was for energy conservation or other purposes. Meanwhile, the objective knowledge items were directed towards energy literacy and whether or not the respondents understood how best to use their devices to conserve energy (e.g., whether it saves more energy to unplug a device from the power strip or turn off the entire strip). A lack of knowledge regarding the ideal method for saving energy given the available devices would not necessarily negatively affect participants' perspectives regarding the process of using these devices. Second, several of the objective knowledge items referred to the functionality of motion sensor lighting, but only participants residing in one of the dormitories had these types of lights. Thus, for the majority of the participants, their objective lighting understanding recorded by these items (while important for understanding user understanding of the increasing number of spaces with motion sensor lighting) did not directly reflect their knowledge of the lights in their own rooms. Finally, a respondent's level of objective knowledge regarding how best to conserve energy is not necessarily indicative of their engagement behaviors aimed at energy conservation. Rather, it illustrates that well-intended action can still occur, even if it is not necessarily executed in the most effective manner. Building upon current theory and research findings (e.g., DeWaters & Powers, 2011), energy literacy education should encompass both hands-on opportunities for learning as well as discussion of specific real-world energy conservation behaviors. In this way, procedural knowledge can be further studied in terms of both its impact on subjective confidence with carrying out a behavior, as well as an accurate and relevant behavioral outlet for environmental concern.

From the standpoint of design features of amenities, these findings point to the need for, not just research on methods for improving comprehension (e.g., more clearly written manuals), but also a possible need for development of training, both of which the HF/E community is well-suited to contribute through research and design. Relatively few participants (fewer than 10%) engaged in information-seeking behaviors, but these behaviors were related to slightly lower levels of objective knowledge, suggesting that those who need more information do seek it out. Furthermore, it seems that it may be most helpful to proactively provide this information to building users, rather than expect them to pursue this information on their own. Indeed, prior research has demonstrated the promising role of training for building occupant use of the devices for the purposes of conserving energy (Day & Gunderson, 2015). However, more research regarding identifying the key procedural training needs for interacting with devices is needed. In terms of the most basic interactions with the built environment, it may be helpful for dormitory resident advisors, landlords, or building managers to provide resources, such as a manual, outline of steps involved, or a Quick Response (QR) code that can be scanned by a smart phone directly from the device that would be linked to a tutorial, or a brief in-person training regarding the process of using so that users have an accurate understanding regarding their use and feel confident in their competency. Furthermore, in cases where the potential for energy savings can only be realized when features are fully comprehended, the cost-tradeoff of implementing training programs in a variety of settings, such as dormitory move-in events, protocols for new residents in multifamily housing, and at employee events for larger companies, for example, needs to be examined.

Third, user perception of ease was also predictive of pro-environmental behaviors. As with past usability research (Hua, Oswald, & Yang, 2011), participants who reported that they found their devices were easy to operate were more likely to use them to engage in PEB. Additionally, ease of use was related to subjective understanding, suggesting that well-understood devices are perceived as easier to use. This is an important finding in terms of existing theory and research regarding the relationships between factors that are specific to energy conservation research, such as the role of the “forgiveness factor” (Deuble & de Dear, 2012) and whether this influence extends to the perception of ease with engaging using certain devices to engage in PEB. The ease of unplugging a device or turning off a power strip is dependent on the number and location of power outlets and the degree of sacrifice involved with accessing a potentially difficult-to-reach outlet, or one that is being used for other devices, in order to do so. A user’s perception of both knowledge and ease regarding how to use the power outlets to conserve energy involves the recognition of this process. However, the perception of knowledge and ease for using the thermostat and light switches involves not only the process of reaching the controls for these devices, but also understanding their individual buttons, functionality, and limitations. Thus, the perception of ease is dependent upon not only how difficult the process of accessing a control is, but also what happens when it is operated – something that may be influenced by the knowledge of what will happen. When this process is perceived as easy, individuals may be more inclined to engage in these behaviors, but when it is difficult, they may be less likely to even try. The HF/E work regarding mental models could be especially helpful towards addressing this particular concern, as perceived difficulty does not

directly prevent these behaviors (the way a complete lack of understanding regarding how to use a device could), but provides an additional usability barrier to behavior adoption that can be further addressed through an integrated approach that encompasses both amenity design as well as user training development.

Fourth, the results demonstrated that user control was also related to energy conservation behaviors. When users reported that they were capable of controlling their devices, they were more likely to engage in these behaviors. Indeed, as depicted in prior research (Brown & Cole, 2009), it seems plausible that users who could not effect change through their interactions with these devices would not feel confident in their use for energy conservation. If a user cannot control their lights, for whatever reason, they are less likely successfully engage in the simple act of turning them off when leaving a room to save energy. Additionally, users are often satisfied by the ability to control the environment, even when the ideal ambient conditions are not reached (Nikolopoulou & Steemers, 2003). In this way, user control may have afforded some degree of satisfaction with the environment that allowed PEB to seem less threatening to respondents' comfort. However, additional research is needed in order to identify the mechanisms responsible for improving perceived control.

User perception of control was also related to subjective understanding and ease of use, as reflected in past research (Brager, Paliaga, & de Dear, 2004; Nikolopoulou & Steemers, 2003) suggesting that the process of interaction with these devices encompasses several related facets, which inform one another; knowledge allows for interaction with the devices, ease determines the level of difficulty with carrying them out, and control demonstrates, perhaps, the degree to

which this process is resulting in successfully changing the environment by using the devices. Although future research is needed to determine a predictive model that includes the directionality of these relationships and how they inform one another through a feedback loop across each interaction, these findings demonstrate how features within the built environment can work in conjunction to produce an influential context regarding the ‘how’ of sustainability that can drive the execution of these behaviors. Beyond the strictly attitudinal considerations of previously studied concepts, such as locus of control (Allen & Ferrand, 1999) and efficacy (Bandura, 1997), this issue presents a usability opportunity on behalf of the HF/E community.

Environmental Attitudes

This study also showed how attitudes regarding the perceived importance about the impact of respondents’ behaviors towards influencing climate change was predictive of their reports of engaging in environmentally sustainable behaviors, as reflected in prior research and theory (e.g., Kollmuss & Agyeman, 2002). This shows the important role of knowledge-based motivation when considering how the built environment can lead to behavior changes that produce a reward not immediately perceivable (e.g., reductions in energy usage for the purposes of positively influencing the environment). Unlike typical interactions within the built environment that serve results-based comfort, these behaviors require a different type of rationale, purpose, or ‘why’ component, thus requiring a distinct form of climate-focused competency. Furthermore, despite the variety of potential environmental orientations and their influence, a basic understanding regarding the desired end-goal (e.g., conserving energy for the purpose of positively influencing the environment) is required to drive and direct behaviors.

In this study, participants generally reported feeling confident in their subjective understanding regarding the importance of climate change, rather than being skeptical or uncertain. However, participants' reported knowledge regarding the general importance of climate change was stronger and more predictive of reported behaviors than their reported understanding regarding the importance of the specific energy-saving behaviors at UCF. The connection in understanding between human behavior and climate change seemed to become weaker as the actions and their location became more specific, as demonstrated in previous research (Lee, 2010). Potential explanations include the lack of visibility regarding the immediate consequences of individual actions, particularly related to energy conservation, individual efficacy concerns, and lack of understanding regarding the impact of comparing one PEB to another (such as the outcome of eating only organically vs. riding a bicycle to class vs. unplugging devices).

Although a large portion of social science research and theory over the last several decades has focused on the attitudinal component of PEB, this study is one of few that have addressed the call for a focus on environmental attitudes in the context of the built environment (e.g. Steg & Vlek, 2009), particularly regarding the specific tasks and possible physical barriers involved in energy conservation. These findings provide further support for the role of attitudes in encouraging PEB and demonstrate a need for additional HF/E research in the built environment context of energy-related behaviors, as well as for further development of information and resources that connect individual energy conservation actions to their impact on climate change.

Combined Influence of Built Environment Factors and Environmental Attitudes

One of the most significant findings of the study emerged when developing a predictive model for energy conservation behaviors in this study; participants were more likely to engage in these self-reported behaviors when they were supported by the features within the built environment (in terms of procedural knowledge, ease of use, and control) and their importance was understood in terms of its impact on the climate. Prior research has demonstrated the influence from environmental attitudes (Gifford, 2014) and, to a lesser extent, the built environment (Deuble & de Dear, 2012), in predicting one's likelihood to participate in PEB in past research, but not the combined impact of specific attitudinal and design factors on energy conservation when measured together. Specifically, little has been explored regarding building users' perception regarding the specific process of conducting the same energy-saving behaviors across different devices and spaces. This finding highlights the utility of considering both the motivation required to drive these behaviors and contextual barriers that may prevent them, specifically the role as the usability of the devices through which they must occur, which has been previously identified as an area of both theory and practice that is ripe for further research (Steg & Vlek, 2009). This intersection between knowledge and design is another gap readily filled by the knowledge and expertise of the HF/E community.

When both the motivation for the behaviors, as well as the context which they must occur are observed, researchers are better able to make inferences into not only what is driving the behaviors, but also identify the factors that require further study. In doing so, the HF/E community can focus research efforts on the components that will maximize the desired behavioral outcomes. The findings from this study demonstrated that pro-environmental attitudes

had the most impact when users were able to adjust their devices. Further research should investigate this additive relationship, both regarding the individual built environment factors, as well as the environmental attitudinal components, to determine the ideal combination of competency and usability for PEB in this area.

Awareness of Kill-A-Watt Competition

The majority of respondents reported awareness of the Kill-A-Watt Competition by T2, and, the more familiar they were with the campaign, the more likely they were to both engage in the behaviors suggested by the campaign, as well as specifically report participation in the competition. Since the campaign materials, including the website, only included a list of energy conservation behaviors (those central to this study) and the possible scholarship prizes, there was no additional environmental educational component or direct resources regarding how to use the devices within the dorms. Instead, it seems that the simple cue-based campaign message was designed as a prompt for dormitory residents' exposure to prior educational campaigns and programs (e.g., Lo, Chow, & Cheung, 2012; Moezzi, Gossard, & Lutzenhiser, 2002) provided was successful in encouraging the desired behaviors, as has been demonstrated in past research (Osbaldiston & Schott, 2011). Since awareness of the campaign was related to several of the other factors, but, when studied together with them, did not provide a significant unique predictive quality, it's possible that exposure to these materials instead provided a source of priming to that energy-saving behaviors are important and/or worthwhile in terms of the incentives provided or, for a small group of participants, led to seeking out additional information to better understand how to use their devices. However, without more explicit

information regarding the campaign's direct influences beyond the scope of this study, I can only infer that awareness influenced participation, but that an understanding regarding the importance of these behaviors and attitudes towards one's environment are stronger predictors of whether or not one will actually participate. Going forward, it would be interesting to explore the role of these types of energy-conservation prompts over a longer period of time, as well as through multimodal exposure (such as signs posted in a dorm room vs. text prompts vs. an online platform), to better understand the longevity of their influence and identify the most effective opportunities to prevent attenuation to them.

Limitations and Future Research

Demographic Factors

The current study utilized a convenience sample of college students, which was potentially problematic due to the pro-environmental influences of education, environmental knowledge from exposure to a variety of variables including course content, clubs and organizations. These factors may have caused a bias in the sample, reflecting more pro-environmental attitudes than are typically found in the general population. Additionally, these experiences may have occurred at some point throughout the course of the study, lending additional influence that was not captured in the survey. The voluntary nature of the study may have attracted a self-selected group of more pro-environmentally-oriented individuals rather than a more random sample.

The housing communities may have demonstrated unique differences across their residents that were not measured in the study. For example, there may be systematic differences among

residents of the more affordable, older dormitories versus those living in the newer communities, or those who prefer to live alone versus those willing to share a space with roommates versus roommates and suitemates. The University of Central Florida also offers Living Learning Communities, where students with similar interests or majors can live together, and the concentrated population of certain demographics, such as health and wellness enthusiasts in one dormitory or Honors students in another dormitory may have influenced certain attitudinal components, and, consequently, their PEB and/or campaign participation.

The relationship between pro-environmental attitudes and behaviors often varies across cultures and can become particularly complex when comparing general, holistic attitudes toward specific behaviors, such as those suggested in the Kill-A-Watt Competition. For example, those holding collectivist views, such as those from Asian countries, for example, may be more likely to demonstrate a stronger connection between general attitudes and specific energy-saving behaviors than those with more individualistic views, for whom specific attitudes would be a stronger predictor, for example (Nisbett, Peng, Choi, & Norenzayan, 2001). Since over 75% of participants in the current study identified as Caucasian, which may include those from Western cultures, many of which hold traditionally more individualistic views, this research may have not adequately captured the variance attributed to potential cultural differences. Additionally, there are gender considerations that may have played a role in these findings. Past research has demonstrated that women tend to exhibit more pro-environmental attitudes and behaviors (Allen & Ferrand, 1999), and even perceived control over energy-related devices (Stevenson, Carmona-Andreu, & Hancock, 2013). Since 73% of the current sample was comprised of women, this may

have contributed towards both a skewed sample as well as ceiling effect for reporting understanding regarding climate change, user control, and reported behaviors. Further investigation is needed to substantiate whether gender is significant in relation to people's perception of environmental controls in housing, and whether this is related to their relative capabilities or other factors.

Methodological Considerations

This study utilized a field sample of residents across all the dormitories on UCF's main campus who responded to the same outreach efforts and protocol previously used for an annual, campus-wide campaign, with the purpose of observing and investigating differences in perceptions, attitudes, and behaviors among residents. Due to the nature of the study, there was no control group or opportunity to compare different campaign strategies across communities, although it is known that the source and presentation of information may influence PEB adoption within environmental campaigns (Arbuthnott, 2009; Corral-Verdugo & Frias-Armenta, 2006). Additionally, despite differences in floor plans and building age, the amenities available were generally similar, with the exception of motion sensor lighting in one dormitory and timed bathroom lighting in one other dormitory. Further insight could be gained from applying study controls or manipulations, particularly in light of the findings from this study, such as amenity training or behavioral suggestions that are tailored to the level of device adjustability for each community, as well as studying a more varied sample of housing amenities as they become developed in newer housing or retrofitted in older communities.

At present, the University of Central Florida's energy consumption data is measured at the building level for all communities except one, which has floor-level data. Without room-specific data or 100% participation rates across floors or buildings, it was not possible to utilize actual data consumption to verify behaviors or direct campaign participation. As a result, the study relied on self-reported data, which is potentially problematic due to biases in social desirability, "green guilt", overestimation of behaviors, and other inaccuracies (Roxas & Lindsay, 2012). As submetering technology and other forms of whole building data access for individual spaces becomes available, actual consumption data should be pursued for similar research efforts in order to better compare the outcomes of self-report measures to traditional building performance measures (see Hoffman & Henn, 2005). Furthermore, it's possible that participants learned about the competition through the emailed survey, skewing the results for reported awareness and familiarity of the campaign. In order to address this concern, it may be helpful to ask the participants of future research to identify specific campaign goals and resources to better gauge their awareness of the competition.

Measurement Considerations

In order to measure the immediate influence of the campaign, a two-part, repeated measures study design was utilized. However, future research may consider the long-term influence of this campaign, with a more longitudinal design. It would be particularly interesting to investigate whether these behaviors resumed for those who continued to live on campus or transferred to a new living space following the spring semester. It may also be helpful to begin studying user behavior upon the resident's initial move-in in order to better understand the iterative, feedback-

based process (see Bamberg & Moser, 2007) of developing their perceptions of knowledge, ease of use, and control of the devices in their room. In this way, an initial measure of reported comfort upon move-in may provide interesting insight regarding the role of a “forgiveness factor” upon the introduction of a sustainability-related campaign (Deuble & de Dear, 2012). Furthermore, since feedback was provided once throughout the competition, at the halfway point between T1 and T2, it’s possible that there was a spike in participation in energy conservation behaviors in response to this information that was not captured in the current study. Future research might also explore the promising component of regular energy performance (Hodge, 2010) or interactive programs designed to increase user knowledge (Brewer, 2013).

For the sake of simplicity and consistency, this research focused on four of the six behaviors encouraged in the Kill-A-Watt Competition; with the suggestion to “give computers a break” considered as a device-unplugging, outlet-specific activity. Other behaviors included switching to compact fluorescent lights (CFLs) and taking shorter showers. The act of switching out light bulb types was not measured in the study since this action would mostly apply to personal lamps and are a one-time behavior (versus to something carried out day-to-day), and thus would be difficult to quantify in a manner consistent with the other behaviors. Additionally, the suggestion was to take shorter showers, rather than adjust the heat involved, presenting task components that were different from the other behaviors measured in the study, as well as a behavior that is typically more associated with water conservation and thus deviated from the other behaviors measured.

Future research may consider varying the language used when describing two built environment components: “hallway” and “adjustable”. The floorplans available across the different housing communities on campus at UCF included traditional living rooms within the private dorm room and others with only a corridor. Upon review of these differences, the terms “hallway” and “common area” were used to describe the space outside of one’s bedroom and bathroom, where additional light switches would be located. However, some participants may have confused this term with the building’s hallway that leads to the main door of each private dorm room, where there are no light controls available for use by residents. Furthermore, participants who responded that they had motion sensor lighting were also asked whether this lighting was “adjustable”, meaning that it could be manually turned on or off. It’s possible that participants may have mistaken this term to mean that the level of lighting could be varied or dimmed. There does not seem to be broadly-applied or commonly-used terms for either the communal spaces referenced above or for this type of light switch functionality. Consequently, future survey items should include explicit descriptions and/or illustrations to ensure that participants are responding accurately.

Limitations Regarding Focus and Scope

The PEB encouraged, measured, and studied in this research included only three simple behaviors and devices that have been previously investigated in the literature, but did not address all possible energy-related PEBs, nor can their findings be generalized to other PEBs, particularly those outside the realm of energy behaviors, such as recycling or transportation

(Whitmarsh & O'Neill, 2010). Future research could explore the use of additional or alternative PEBs and how these variables may interact differently for these domains as well.

Additionally, the results of these hypotheses provide several interesting and useful insights into the relationships between the variables measured and participation in the Kill-A-Watt Competition and its related behaviors, but they do not provide information regarding the various other factors that influence PEB. For example, the influence of the incentive was not directly investigated in relation to the other factors, although it is known that this likely influenced PEB (Stern, Aronson, Darley, Kempton, Hill, Hirst, & Wilbanks, 1987). This influence of incentives is of particular interest for dormitory residents since they pay a flat rate for housing and do not incur direct costs or regular feedback from their energy consumption through monthly utility bills, which is often used for ongoing energy management, as well as participation in energy conservation campaigns that span the larger commercial sector, such as the Better Buildings Challenge (U.S. Department of Energy, n.d.) or the Battle of the Buildings (U.S. Environmental Protection Agency, n.d.). Furthermore, other concepts, such as individual efficacy, collective efficacy, and other motivational factors could all provide important insight regarding the degree to which individuals feel capable of influencing change through these behaviors (Gifford, 2014). Since these behaviors occur within the context of a communal residence and social competition, other factors, such as social diffusion likely influenced their participation (Yates & Aronson, 1983) and should be measured in future research.

Other specific choices made for the purposes of the current study included the decision to focus heavily on subjective understanding, rather than providing educational opportunities to improve objective energy literacy, as well as measuring comfort as a result of the process of interacting with devices, rather than as an outcome state. Although both of these choices were made based on their demonstrated utility in the current literature (Doulos et al., 2007; Kaiser & Fuhrer, 2003), future research may consider studying these components in tandem with their alternatives to develop a more robust predictive model of PEB. Additionally, the items and structure of the surveys require further validation as the scale development was relatively preliminary.

Finally, in light of the variety and number of potential limitations and suggestions for additional research, it's important to mention that, in terms of environmental research, it would be impossible to design a meaningful model that takes into account the enormous number of contributing factors toward PEB (Kollmuss & Agyeman, 2002). However, since researchers have suggested that contextual barriers are an important component within existing PEB theory, but require further study for identification and consideration, (Monroe, 2003; Steg & Vlek, 2009) the findings from this research contribute to existing theory across sustainability science by identifying a comprehensive set of several, previously disparate concepts that are related to energy-saving behaviors. Specifically, this research has revealed that procedural knowledge, ease of use, and control, as a relevant set of factors for understanding energy-related PEB within the context of the built environment. Further study and review can help to specify the unique individual relationships between these factors and others, which can provide a step towards a

more general understanding regarding how to encourage PEB and influence usability across built environment design to optimize the future implementation of energy conservation efforts and maximize the positive impact on the environment.

Conclusion

In this dissertation, I explored the influence of the design of amenities within the built environment, environmental attitudes, and awareness of an environmental campaign on energy-saving behaviors. Whereas previous research has focused on either design elements or attitudinal factors, the central goal of this work was to redress the gap between these areas of study. Therefore, I investigated the potential influence of these variables when considered together and also examined the degree to which awareness of the campaign had an influence.

Consistent with prior research, the findings from this study indicated that factors within the built environment, such as amenity adjustability and subjective perception of ease of use and control, were significant predictors of pro-environmental behaviors. As such, these factors may have provided an influential context in which behaviors (and behavior change) could occur. Additionally, user knowledge, which has been less studied than the other factors, was found to be one of the strongest predictors of behaviors. This knowledge perhaps served as a mechanism that unlocked the opportunity to effectively utilize the amenity and guide the outcome of these interactions.

Also consistent with previous work, the attitudinal factor, subjective knowledge regarding the importance of climate change, was a significant predictor of these behaviors. Beyond the more traditional impetus for making changes to improve a room's comfort, this

understanding served as a motivational force for driving interactions with the built environment towards the distal goal of sustainability.

Additionally, in line with the focus of this research, each of these distinct components provided significant prediction of energy-saving behaviors, but their influence increased significantly when measured together. Specifically, participants were more likely to engage in energy conservation when both the contextual factors enabled behaviors and were well understood and the individual reported attitudes that steered their behaviors towards energy conservation.

Campaign awareness was also predictive of self-reported campaign participation as well as demonstrating a positive impact on the actual behaviors that were targeted by the campaign. This suggests that the campaign was successful in significantly affecting behavior change across the course of the competition for the participants of this study.

Generally considering the relationship between HF/E and sustainability, this work highlights an important opportunity for the application of HF/E methods for understanding user interactions with the built environment. The burgeoning area of study and development that has been coined “green ergonomics” transcends the basic aspects of design and extends to include a more general approach towards connecting humans and the natural environment and is defined as “ergonomics interventions that have a pro-nature focus; specifically ergonomics that focuses on human affinity with the natural world.” (Thatcher, p. 391, 2013). As such, in order to be most effective, consideration of design must include further study of the other relevant variables and the larger context in which these variables interact.

The findings from this research indicate that design components of the built environment, in combination with the attitudes held by individuals within that environment, have a strong influence that can be further targeted and influenced through an energy conservation campaign. By addressing a gap in HF/E research about the relationship between attitudinal factors and the built environment, this dissertation provides a unique contribution to the field and points the way towards development of promising, comprehensive solutions for encouraging sustainable behaviors.

APPENDIX A: FEBRUARY SURVEYS

A. Biodata Scale

1. Age _____
2. Class
 - a. Freshmen
 - b. Sophomore
 - c. Junior
 - d. Senior
 - e. Graduate Student
3. Transfer Student
 - a. No
 - b. Yes
 - i. If so, when did you transfer? _____
4. When did you move into your current dorm?
 - a. Month: _____
 - b. Year: _____
5. Are you Hispanic or Latino? (A person of Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin, regardless of race.)
 - a. Yes
 - b. No
6. Race
 - a. **American Indian or Alaska Native.** A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
 - b. **Asian.** A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
 - c. **Black or African American.** A person having origins in any of the black racial groups of Africa.
 - d. **Native Hawaiian or Other Pacific Islander.** A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
 - e. **White.** A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.
7. Gender
 - a. Female
 - b. Male

- c. Transgender female
 - d. Transgender male
 - e. Prefer not to answer
8. Major _____
9. Housing
- a. What is the name of your housing community?

 - b. Which of the following best describes your place of housing:
 - i. Bedroom:
 - 1. Private bedroom
 - 2. Bedroom shared with one roommate
 - ii. Number of bedrooms:
 - 1. One
 - 2. Two
 - 3. Three
 - 4. Four
 - iii. Number of bathrooms:
 - 1. One
 - 2. Two
 - iv. Furnishings:
 - 1. Furnished
 - 2. Unfurnished
 - v. Other rooms:
 - 1. Kitchen
 - 2. Common area/living room

B. Amenities Within the Built Environment

Please indicate whether your residence hall has the following amenities:

- a. Motion sensor light in hall/shared area of my dorm room
 - i. No
 - ii. Yes
 - iii. I don't know
 1. If yes, can this light be adjusted?
 - a. No
 - b. Yes
 - c. I don't know
- b. Motion sensor light in my bedroom
 - i. No
 - ii. Yes
 - iii. I don't know
 1. If yes, can this light be adjusted?
 - d. No
 - e. Yes
 - f. I don't know
- c. Motion sensor lights in my bathroom
 - i. No
 - ii. Yes
 - iii. I don't know
 1. If yes, can this light be adjusted?
 - a. No
 - b. Yes
 - c. I don't know
- d. Thermostat that can be adjusted
 - i. No
 - ii. Yes
 - iii. I don't know

1. If yes, is there a limited range of temperatures?
 - a. No
 - b. Yes
 - c. I don't know

C. Kill-A-Watt Behaviors

1. I turn off the lights when I leave the hall/shared area of my dorm room

1 Never	2	3	4	5	6 Always
------------	---	---	---	---	-------------

2. I turn off the lights when I leave my bedroom

1 Never	2	3	4	5	6 Always
------------	---	---	---	---	-------------

3. I turn off the lights when I leave my bathroom

1 Never	2	3	4	5	6 Always
------------	---	---	---	---	-------------

4. I raise the thermostat whenever I leave my dorm room

1 Never	2	3	4	5	6 Always
------------	---	---	---	---	-------------

5. I unplug devices and/or turn off a power strip whenever I am not using them in my dorm room

1 Never	2	3	4	5	6 Always
------------	---	---	---	---	-------------

D. Perception of Knowledge, Ease of Use, and Control With Amenities Within the Built Environment

1. I understand how the lighting is controlled in the hall/shared area of my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

2. I understand how the lighting is controlled in my bedroom

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

3. I understand how the lighting is controlled in my bathroom

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

4. I understand how the thermostat is controlled in my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

5. I understand how to power my devices using the power outlets in my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

6. I find it easy to control the lights in the hall/shared area of my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

7. I find it easy to control the lights in my bedroom

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

8. I find it easy to control the lights in my bathroom

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

9. I find it easy to control the thermostat in my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

10. It is easy to plug and unplug the devices in my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

11. I am happy with my ability to use the light switches to control the level of lighting in the hall/shared area of my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

12. I am happy with my ability to use the light switches to control the level of lighting in the in
my bedroom

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

13. I am happy with my ability to use the light switches to control the level of lighting in the in
my bathroom

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

14. I am happy with my ability to use the thermostat to control the temperature

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

15. I am happy with the number of power outlets in my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

16. I am happy with the locations of the power outlets in my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

E. Knowledge Regarding How to Use Amenities Within the Built Environment

1. The motion sensor lights turn off:
 - a. As soon as I stop moving or leave the room
 - b. After a set period of time without motion or activity

2. I conserve more energy when I:
 - a. Let the motion sensor lights to turn off on their own when I leave a room
 - b. Manually turn off the lights when I leave a room

3. I conserve more energy when I:
 - a. Always keep the thermostat within a set range of temperatures with little variation, even when I leave my dorm room
 - b. Turn the thermostat up when I leave my dorm room

4. I conserve more energy when I:
 - a. Unplug electrical devices when not in use
 - b. Leave them plugged in, but turn them off

5. I conserve more energy when I:
 - a. Turn off the power strip
 - b. Unplug the devices and leave the power strip on

F. Awareness of Kill-A-Watt

1. Please indicate on a scale from 1-6, your level of awareness with the Kill-A-Watt

Competition **in prior years (2014 or before)?**

1 Completely Unaware	2	3	4	5	6 Completely Aware
----------------------------	---	---	---	---	--------------------------

2. Please indicate how you found out about the Kill-A-Watt Competition **in prior years (2014 or before)**

- a. Email sent out from Housing
- b. Email from UCF Today
- c. Email sent out from other source (Please provide source:_____)
- d. Housing Facebook post
- e. Facebook post from other source (Please provide source:_____)
- f. Article in Central Florida Future
- g. Knightly News
- h. Tabling at Student Union
- i. Tabling at Library
- j. Flyer posted in residence hall
- k. Word of mouth from Resident Advisor

- l. Word of mouth from other student
- m. Other (Please specify:_____)
- n. Other (Please specify:_____)
- o. Other (Please specify:_____)

3. Please indicate on a scale from 1-6, your level of awareness with the Kill-A-Watt

Competition **this current Spring 2015 semester**

1 Completely Unaware	2	3	4	5	6 Completely Aware
----------------------------	---	---	---	---	--------------------------

4. Please indicate how you found out about the Kill-A-Watt Competition **this current Spring 2015 semester**

- a. Email sent out from Housing
- b. Email from UCF Today
- c. Email sent out from other source (Please provide source:_____)
- d. Housing Facebook post
- e. Facebook post from other source (Please provide source:_____)
- f. Article in Central Florida Future

- g. Knightly News
- h. Tabling at Student Union
- i. Tabling at Library
- j. Flyer posted in residence hall
- k. Word of mouth from Resident Advisor
- l. Word of mouth from other student
- m. Other (Please specify:_____)
- n. Other (Please specify:_____)
- o. Other (Please specify:_____)

G. Participation in Kill-A-Watt

1. Have you participated in the Kill-A-Watt Competition by making an effort to conserve energy **in prior years (2014 or before)**?
 - a. No
 - b. Yes

2. Have you participated in the Kill-A-Watt Competition by submitting an essay **in prior years (2014 or before)**?
 - a. No
 - b. Yes

3. Are you or do you plan to participate in the Kill-A-Watt Competition **this current Spring 2015 semester**?
 - a. No
 - b. Yes

H. Seeking Out Knowledge

1. Since moving in, I have sought out information regarding how to use the amenities (such as lights, thermostat, and power outlets) in my dorm room.

- a. No
- b. Yes

i. If yes, from what sources did you obtain your information (i.e., website, roommate, Resident Advisor, etc...)

- 1. Please specify: _____
 - a. Was this information helpful?
 - i. No
 - ii. Yes
- 2. Please specify: _____
 - a. Was this information helpful?
 - i. No
 - ii. Yes
- 3. Please specify: _____
 - a. Was this information helpful?
 - i. No
 - ii. Yes

2. I sought out this information simply to make it easier to use these amenities

1	2	3	4	5	6
Completely Disagree					Completely Agree

3. I sought out this information so that I could take part in energy-saving behaviors

1	2	3	4	5	6
Completely Disagree					Completely Agree

4. I sought out this information so that I could take part in the Kill-A-Watt Competition
in prior years (2014 or before)

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

5. I sought out this information so that I could take part in the Kill-A-Watt Competition
in this current Spring 2015 semester

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

I. Understanding Regarding the Importance of Climate Change

1. I understand why climate change is important for the Earth and all its inhabitants

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

2. I understand why it's important to engage in behaviors that can impact climate change

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

3. I understand why it's important to save energy in general

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

4. I understand why it's important for UCF to save energy

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

5. I understand why it's important to follow Kill-A-Watt behaviors (such as turning off lights, turning up the temperature, and unplugging devices) to save energy

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

APPENDIX B: APRIL SURVEYS

A. Amenities Within the Built Environment

Please indicate whether your residence hall has the following amenities:

- a. Motion sensor light in hall/shared area of my dorm room
 - iv. No
 - v. Yes
 - vi. I don't know
 - 1. If yes, can this light be adjusted?
 - a. No
 - b. Yes
 - c. I don't know
- b. Motion sensor light in my bedroom
 - iv. No
 - v. Yes
 - vi. I don't know
 - 2. If yes, can this light be adjusted?
 - d. No
 - e. Yes
 - f. I don't know
- c. Motion sensor lights in my bathroom
 - iv. No
 - v. Yes
 - vi. I don't know
 - 2. If yes, can this light be adjusted?
 - d. No
 - e. Yes
 - f. I don't know
- d. Thermostat that can be adjusted
 - iv. No
 - v. Yes
 - vi. I don't know

2. If yes, is there a limited range of temperatures?
- d. No
 - e. Yes
 - f. I don't know

B. Kill-A-Watt Behaviors

1. I turn off the lights when I leave the hall/shared area of my dorm room

1 Never	2	3	4	5	6 Always
------------	---	---	---	---	-------------

2. I turn off the lights when I leave my bedroom

1 Never	2	3	4	5	6 Always
------------	---	---	---	---	-------------

3. I turn off the lights when I leave my bathroom

1 Never	2	3	4	5	6 Always
------------	---	---	---	---	-------------

4. I raise the thermostat whenever I leave my dorm room

1 Never	2	3	4	5	6 Always
------------	---	---	---	---	-------------

5. I unplug devices and/or turn off a power strip whenever I am not using them in my dorm room

1 Never	2	3	4	5	6 Always
------------	---	---	---	---	-------------

C. Perception of Knowledge, Ease of Use, and Control With Amenities Within the Built Environment

1. I understand how the lighting is controlled in the hall/shared area of my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

2. I understand how the lighting is controlled in my bedroom

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

3. I understand how the lighting is controlled in my bathroom

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

4. I understand how the thermostat is controlled in my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

5. I understand how to power my devices using the power outlets in my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

6. I find it easy to control the lights in the hall/shared area of my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

7. I find it easy to control the lights in my bedroom

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

8. I find it easy to control the lights in my bathroom

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

9. I find it easy to control the thermostat in my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

10. It is easy to plug and unplug the devices in my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

11. I am happy with my ability to use the light switches to control the level of lighting in the hall/shared area of my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

12. I am happy with my ability to use the light switches to control the level of lighting in the in
my bedroom

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

13. I am happy with my ability to use the light switches to control the level of lighting in the in
my bathroom

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

14. I am happy with my ability to use the thermostat to control the temperature

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

15. I am happy with the number of power outlets in my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

16. I am happy with the locations of the power outlets in my dorm room

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

D. User Knowledge Regarding How to Use Amenities Within the Built Environment

1. The motion sensor lights turn off:
 - a. As soon as I stop moving or leave the room
 - b. After a set period of time without motion or activity

2. I conserve more energy when I:
 - a. Let the motion sensor lights to turn off on their own when I leave a room
 - b. Manually turn off the lights when I leave a room

3. I conserve more energy when I:
 - a. Always keep the thermostat within a set range of temperatures with little variation, even when I leave my dorm room
 - b. Turn the thermostat up when I leave my dorm room

4. I conserve more energy when I:
 - a. Unplug electrical devices when not in use
 - b. Leave them plugged in, but turn them off

5. I conserve more energy when I:
 - a. Turn off the power strip
 - b. Unplug the devices and leave the power strip on

E. Awareness of Kill-A-Watt

5. Please indicate on a scale from 1-6, your level of awareness with the Kill-A-Watt

Competition this **current Spring 2015 semester**

1 Completely Unaware	2	3	4	5	6 Completely Aware
----------------------------	---	---	---	---	--------------------------

6. Please indicate how you found out about the Kill-A-Watt Competition:

- a. Email sent out from Housing
- b. Email from UCF Today
- c. Email sent out from other source (Please provide source: _____)
- d. Housing Facebook post
- e. Facebook post from other source (Please provide source: _____)
- f. Article in Central Florida Future
- g. Knightly News
- h. Tabling at Student Union
- i. Tabling at Library
- j. Flyer posted in residence hall
- k. Word of mouth from Resident Advisor
- l. Word of mouth from other student
- m. Other (Please specify: _____)

n. Other (Please specify:_____)

o. Other (Please specify:_____)

F. Participation in Kill-A-Watt

1. Did you participate the Kill-A-Watt Competition by making an effort to conserve energy **during this current Spring 2015 semester?**
 - a. No
 - b. Yes

2. Did you participate in the Kill-A-Watt Competition by submitting an essay **during this current Spring 2015 semester?**
 - a. No
 - b. Yes

G. Seeking Out Knowledge

1. Since moving in, I have sought out information regarding how to use the amenities (such as lights, thermostat, and power outlets) in my dorm room.

- a. No
- b. Yes
 - i. If yes, from what sources did you obtain your information (i.e., website, roommate, Resident Advisor, etc...)
 - 1. Please specify:_____
 - a. Was this information helpful?
 - i. No
 - ii. Yes
 - 2. Please specify:_____
 - a. Was this information helpful?
 - i. No
 - ii. Yes
 - 3. Please specify:_____
 - a. Was this information helpful?
 - i. No
 - ii. Yes

2. I sought out this information simply to make it easier to use these amenities

1	2	3	4	5	6
Completely Disagree					Completely Agree

3. I sought out this information so that I could take part in energy-saving behaviors

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

4. I sought out this information so that I could take part in the Kill-A-Watt Competition

in prior years (2014 or before)

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

5. I sought out this information so that I could take part in the Kill-A-Watt Competition

in this current Spring 2015 semester

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

I. Understanding Regarding the Importance of Climate Change

1. I understand why climate change is important for the Earth and all its inhabitants

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

2. I understand why it's important to engage in behaviors that can impact climate change

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

3. I understand why it's important to save energy in general

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

4. I understand why it's important for UCF to save energy

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

5. I understand why it's important to follow Kill-A-Watt behaviors (such as turning off lights, turning up the temperature, and unplugging devices) to save energy

1 Completely Disagree	2	3	4	5	6 Completely Agree
-----------------------------	---	---	---	---	--------------------------

APPENDIX C: IRB APPROVAL LETTER



University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Exempt Human Research

From: UCF Institutional Review Board #1
FWA00000351, IRB00001138

To: Brittany C. Sellers and Co-PIs: Florian G. Jentsch, Janan A. Smither, Stephen M. Fiore,
Valerie K. Sims

Date: February 16, 2015

Dear Researcher:

On 02/16/2015, the IRB approved the following activity as human participant research that is exempt from regulation:

Type of Review: Exempt Determination
Project Title: Investigating the Influence of the Built Environment on Energy-Saving Behaviors
Investigator: Brittany C. Sellers
IRB Number: SBE-15-10955
Funding Agency:
Grant Title:
Research ID: N/A

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the [Investigator Manual](#).

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Patria Davis on 02/16/2015 09:34:28 AM EST

IRB Coordinator

LIST OF REFERENCES

- Abbaszadeh, S., Zagreus, L., Lehrer, D., & Huizenga, C. (2006). Occupant satisfaction with indoor environmental quality in green buildings. Center for the Built Environment.
- Abrahamse, W., Steg, L., Gifford, R., & Vlek, C. (2009). Factors influencing car use for commuting and the intention to reduce it: A question of self-interest or morality?. *Transportation Research Part F: Traffic Psychology and Behaviour*, 12(4), 317-324.
- Aertsens, J., Mondelaers, K., Verbeke, W., Buysse, J., & Van Huylenbroeck, G. (2011). The influence of subjective and objective knowledge on attitude, motivations and consumption of organic food. *British Food Journal*, 113 (11), 1353-1378
- Ahlberg, M. (2005). "Integrating Education for Sustainable Development", *Handbook of Sustainability Research*. Ed. W.L. Filho. Frankfurt: Peter Lang. 477-504.
- Ajzen, I. (1991). Theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50, 179-211.
- Ajzen, I. (2005). *Attitudes, personality, and behavior*. McGraw-Hill Education (UK).
- Ajzen, I., & Fishbein, M. (1977). Attitude-behavior relations: A theoretical analysis and review of empirical research. *Psychological bulletin*, 84(5), 888.
- Alahmad, M., Nader, W., Cho, Y., Shi, J., & Neal, J. (2011). Integrating physical and virtual environments to conserve energy in buildings. *Energy and Buildings*, 43(12), 3710-3717.

- Allen, J. B., & Ferrand, J. L. (1999). Environmental locus of control, sympathy, and proenvironmental behavior a test of geller's actively caring hypothesis. *Environment and behavior, 31*(3), 338-353.
- Arbuthnott, K. D. (2009). Education for sustainable development beyond attitude change. *International Journal of Sustainability in Higher Education, 10*(2), 152-163.
- Arnold, H. E., Cohen, F. G., & Warner, A. (2009). Youth and environmental action: Perspectives of young environmental leaders on their formative influences. *The Journal of Environmental Education, 40*(3), 27-36.
- Aronson, E., & Gonzales, M. H. (1990). Alternative social influence processes applied to energy conservation. In *Social influence processes and prevention* (pp. 301-325). Springer US.
- Aronson, E., & O'Leary, M. (1982). The relative effectiveness of models and prompts on energy conservation: A field experiment in a shower room. *Journal of Environmental Systems, 12*(3), 219-224.
- Baker, N., & Standeven, M. (1996). Thermal comfort for free-running buildings. *Energy and Buildings, 23*(3), 175-182.
- Bamberg, S (2003). How does environmental concern influence specific environmentally related behaviors? A new answer to an old question. *Journal of Environmental Psychology, 23*, 21-32.
- Bamberg, S., & Möser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of environmental psychology, 27*(1), 14-25.

- Bamberg, S., & Schmidt, P. (2003). Incentives, morality, or habit? Predicting students' car use for university routes with the models of Ajzen, Schwartz, and Triandis. *Environment and Behavior, 35*(2), 264-285.
- Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist, 37* (2), 122-147.
- Bandura, A. (1994). Self-efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of Human Behavior* (Vol. 4, pp. 71-81). New York: Academic Press.
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W.H. Freeman and Company.
- Bator, R.J., & Cialdini, R.B. (2000). The application of persuasion theory to the development of effective proenvironmental public service announcements, *Journal of Social Issues, 56*(3), 527-541.
- Bauman, F., Carter, T., & Baughman, A. (1998). Field study of the impact of a desktop task/ambient conditioning system in office buildings. Center for the Built Environment.
- Bonte, M., Thellier, F., & Lartigue, B. (2014). Impact of occupant's actions on energy building performance and thermal sensation. *Energy and Buildings 76*, 219–227.
- Bowler, D. E., Buyung-Ali, L. M., Knight, T. M., & Pullin, A. S. (2010). A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health, 10*(1), 456.
- Brager, G., & Baker, L. (2009). Occupant satisfaction in mixed-mode buildings. *Building Research & Information, 37*(4), 369-380.

- Brager, G., Paliaga, G., & de Dear, R. (2004). Operable windows, personal control and occupant comfort. *Center for the Built Environment*.
- Brewer, R. S. (2013). Fostering sustained energy behavior change and increasing energy literacy in a student housing energy challenge. *Computer Science*.
- Broido, E., Campbell, J., (2008). A commentary on “the educational role in college student housing”. *Journal of College and University Student Housing*, 35 (2).
- Brown, Z. (2009). Occupant comfort and engagement in green buildings: Examining the effects of knowledge, feedback and workplace culture [PhD thesis]. Vancouver: University of British Columbia.
- Brown, Z. B., & Cole, R. J. (2008). Engaging occupants in green building performance: addressing the knowledge gap. Proceedings of the 2008 ACEEE Summer Study on Energy Efficiency in Buildings.
- Brown, Z. B., Dowlatabadi, H., & Cole, R. J. (2009). Feedback and adaptive behaviour in green buildings. *Intelligent Buildings International*, 1(4), 296-315.
- Burn, S. M. (1991). Social psychology and the stimulation of recycling behaviors: The block leader approach. *Journal of applied social psychology*, 21(8), 611-629. *and Ergonomics Society*, 54(6), 925-939.
- Burn, S.M. (2013, May 9). *Are you a sustainability hypocrite? Harnessing your cognitive dissonance for sustainability*. Retrieved January 9, 2014 from <https://www.psychologytoday.com/blog/presence-mind/201305/are-you-sustainability-hypocrite>.

- Cao, X., Mokhtarian, P. L., and Handy, S. L. (2007). Do Changes in Neighborhood Characteristics Lead to Changes in Travel Behavior? A Structural Equations Modeling Approach. *Transportation*, 34 (5), 535-556
- Chawla, L., & Cushing, D. F. (2007). Education for strategic environmental behavior. *Environmental Education Research*, 13(4), 437-452.
- Chen, M. F., & Tung, P. J. (2009). The moderating effect of perceived lack of facilities on consumers' recycling intentions. *Environment and Behavior*.
- Cleveland, M., Kalamas, M., & Laroche, M. (2005) Shades of green: linking environmental locus of control and pro-environmental behaviors. *The Journal of Consumer Marketing*, 22 (4), 198-212.
- Cole, R.J. (2010). Green buildings and their occupants: a measure of success. *Building Research & Information*, 38(5), 589-592.
- Collins, T. (2010). Behavior, comfort, and energy consumption in student residence halls. Master's thesis, University of Oregon, 2010.
- Coltrane, S., Archer, D., & Aronson, E. (1986). The social-psychological foundations of successful energy conservation programmes. *Energy Policy*, 14(2), 133-148
- Corral-Verdugo, V., Bechtel, R. B., & Fraijo-Sing, B. (2003). Environmental beliefs and water conservation: An empirical study. *Journal of Environmental Psychology*, 23(3), 247-257.
- Corral-Verdugo, V., Bonnes, M., Tapia-Fonllem, C., Fraijo-Sing, B., Frías-Armenta, M., & Carrus, G. (2009). Correlates of pro-sustainability orientation: The affinity towards diversity. *Journal of Environmental Psychology*, 29(1), 34-43.

- Corral-Verdugo, V., & Frías-Armenta, M. (2006). Personal normative beliefs, antisocial behavior, and residential water conservation. *Environment and Behavior*, 38(3), 406-421.
- Corral-Verdugo, V., Mireles-Acosta, J., Tapia-Fonllem, C., & Fraijo-Sing, B. (2011). Happiness as correlate of sustainable behavior: A study of pro-ecological, frugal, equitable and altruistic actions that promote subjective wellbeing. *Human Ecology Review*, 18(2), 95-104.
- Costanzo, M., Archer, D., Aronson, E., & Pettigrew, T. (1986). Energy conservation behavior: The difficult path from information to action. *American Psychologist*, 41(5), 521.
- Day, J. K., & Gunderson, D. E. (2015). Understanding high performance buildings: The link between occupant knowledge of passive design systems, corresponding behaviors, occupant comfort and environmental satisfaction. *Building and Environment*, 84, 114-124.
- de Dear, R. J., & Brager, G. S. (2002). Thermal comfort in naturally ventilated buildings: revisions to ASHRAE Standard 55. *Energy and Buildings*, 34(6), 549-561.
- de Groot, J. I., & Steg, L. (2010). Relationships between value orientations, self-determined motivational types and pro-environmental behavioural intentions. *Journal of Environmental Psychology*, 30(4), 368-378.
- DeWaters, J. E., & Powers, S. E. (2011). Energy literacy of secondary students in New York State (USA): A measure of knowledge, affect, and behavior. *Energy Policy*, 39(3), 1699-1710.

- Deuble, M. P., & de Dear, R. J. (2012). Green occupants for green buildings: the missing link? *Building and Environment*, 56, 21-27.
- Devine-Wright, P., Devine-Wright, H., & Fleming, P. (2004). Situational influences upon children's beliefs about global warming and energy. *Environmental Education Research*, 10(4), 493-506.
- Dickerson, C. A., Thibodeau, R., Aronson, E., & Miller, D. (1992). Using Cognitive Dissonance to Encourage Water Conservation. *Journal of Applied Social Psychology*, 22(11), 841-854.
- Dietz, T., & Stern, P. C. (Eds.). (2002). *New tools for environmental protection: Education, information, and voluntary measures*. National Academies Press.
- Dillahunt, T., Mankoff, J., Paulos, E., & Fussell, S. (2009, September). It's not all about green: Energy use in low-income communities. In *Proceedings of the 11th International Conference on Ubiquitous Computing*, 255-264. ACM.
- Doulos, L., Tsangrassoulis, A., & Topalis, F. V. (2007, December). Evaluation of lighting controls in office buildings. In *Proceedings of the Sixth WSEAS International Conference on Circuits, Systems, Electronics, Control & Signal Processing*, Cairo, Egypt.
- Eagles, P. F., & Demare, R. (1999). Factors influencing children's environmental attitudes. *The Journal of Environmental Education*, 30(4), 33-37.
- Ellen, P. S. (1994). Do we know what we need to know? Objective and subjective knowledge effects on pro-ecological behaviors. *Journal of Business Research*, 30(1), 43-52.

- Farmer, J., Knapp, D., & Benton, G. (2007). An Elementary School Environmental Education Field Trip: Long-Term Effects on Ecological and Environmental Knowledge and Attitude Development. *The Journal of Environmental Education*, 38(3), 33-42.
- Feinberg, M., & Willer, R. (2013). The moral roots of environmental attitudes. *Psychological Science*, 24(1), 56-62.
- Ferguson, M. A., & Branscombe, N. R. (2010). Collective guilt mediates the effect of beliefs about global warming on willingness to engage in mitigation behavior. *Journal of Environmental Psychology*, 30(2), 135-142.
- Fiore, S.M., Phillips, E., & Sellers, B. (2014). A transdisciplinary perspective on hedonomic sustainability. *Ergonomics*.
- Fong, K. F., & Lee, C. K. (2012). Towards net zero energy design for low-rise residential buildings in subtropical Hong Kong. *Applied Energy*, 93, 686-694.
- Frick, J., Kaiser, F. G., & Wilson, M. (2004). Environmental knowledge and conservation behavior: Exploring prevalence and structure in a representative sample. *Personality and Individual Differences*, 37(8), 1597-1613.
- Gärling, T., Biel, A., & Gustafsson, M. (2002). The new environmental psychology: The human interdependence paradigm. *Handbook of environmental psychology*, 85-94.
- Gifford, R. (2014). Environmental psychology matters. *Psychology*, 65(1), 541.
- Gifford, R., & Nilsson, A. (2014). Personal and social factors that influence pro-environmental concern and behaviour: A review. *International Journal of Psychology*, 49(3), 141-157.

- Goins, J. & Moezzi, M. (2013). Linking occupant complaints to building performance, *Building Research & Information*, 41(3), 361–372.
- Gonzales, M. H., Aronson, E., & Costanzo, M. A. (1988). Using Social Cognition and Persuasion to Promote Energy Conservation: A Quasi-Experiment. *Journal of Applied Social Psychology*, 18(12), 1049-1066.
- Green-Demurs, I., Pelletier, L.G., & Menard, S. (1997). The impact of behavioral difficulty on the saliency of the association between self-determined motivation and environmental behaviors. *Canadian Journal of Behavioral Science*, 29 (3), 157-166.
- Grønhøj, A., & Thøgersen, J. (2009). Like father, like son? Intergenerational transmission of values, attitudes, and behaviours in the environmental domain. *Journal of Environmental Psychology*, 29(4), 414-421.
- Hanson, M.A. (2013) Green ergonomics: challenges and opportunities, *Ergonomics*, 56(3), 399-408.
- Hartkopf, V.H., Loftness, V.E., & Mill, A.D.P. (1986). The concept of total building performance and building diagnostics, *Building Performance: Function, Preservation, and Rehabilitation*, 5–22.
- Hassanain, M. A. (2008). On the performance evaluation of sustainable student housing facilities. *Journal of Facilities Management*, 6 (3).
- Hawkes, D. (1982). The theoretical basis of comfort in the ‘selective’ control of environments. *Energy and Buildings*, 5(2), 127-134.

- Heath, Y., & Gifford, R. (2006). Free-market ideology and environmental degradation the case of belief in global climate change. *Environment and Behavior*, 38(1), 48-71.
- Hedge, A., & Dorsey, J. A. (2013). Green buildings need good ergonomics. *Ergonomics*, 56(3), 492-506.
- Hine, D. W., Gifford, R., Heath, Y., Cooksey, R., & Quain, P. (2009). A cue utilization approach for investigating harvest decisions in commons dilemmas. *Journal of Applied Social Psychology*, 39(3), 564-588.
- Hodge, C. (2010, November). *Dorm energy competitions: Passing fad or powerful behavior modification tool?* Presentation at the 2010 Behavior Energy and Climate Change Conference.
- Hoffman, A. J., & Henn, R. (2008). Overcoming the social and psychological barriers to green building. *Organization & Environment*, 21(4), 390-419.
- Hua, Y., Oswald, A., & Yang, X. (2011). Effectiveness of daylighting design and occupant visual satisfaction in a LEED Gold laboratory building. *Building and Environment*, 46(1), 54-64.
- Janda, K. B. (2011). Buildings don't use energy: people do. *Architectural Science Review*, 54(1), 15-22.
- Jaus, H. H. (1984). The development and retention of environmental attitudes in elementary school children. *The Journal of Environmental Education*, 15(3), 33-36.

- Kaiser, F. G., & Byrka, K. (2011). Environmentalism as a trait: Gauging people's prosocial personality in terms of environmental engagement. *International Journal of Psychology, 46*(1), 71-79.
- Kaiser, F. G., & Fuhrer, U. (2003). Ecological behavior's dependency on different forms of knowledge. *Applied Psychology, 52*(4), 598-613.
- Kals, E., & Ittner, H. (2003). *Children's environmental identity, indicators and behavioral impacts*. The MIT Press, Cambridge, Massachusetts.
- Kamilaris, A., Kitromilides, G., & Pitsillides, A. (2012, April). Energy Conservation through Social Competitions in Blocks of Flats. In *SMARTGREENS*, 167-174.
- Kaplan, S., & Kaplan, R. (2009). Creating a larger role for environmental psychology: The Reasonable Person Model as an integrative framework. *Journal of Environmental Psychology, 29*(3), 329-339.
- Katzeff, C., Broms, L., Jönsson, L., Westholm, U., & Räsänen, M. (2013). Exploring Sustainable Practices in Workplace Settings through Visualizing Electricity Consumption. *ACM Transactions on Computer-Human Interaction (TOCHI), 20*(5), 31.
- Keinonen, T., Yli-Panula, Y. P., Svens, M., Vilkonis, R., Persson, C., & Palmberg, I. (2014). Environmental Issues in the Media—Students' Perceptions in the Three Nordic-Baltic Countries. *Journal of Teacher Education for Sustainability, 16*(1), 32-53.
- Kollmuss, A. & Agyeman, J. (2002). Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research, 8* (3), 239-260.

- Kuijer, L., & de Jong, A. (2009, December). A practice oriented approach to user centered sustainable design. In *Ecodesign 2009 Conference*.
- Kwok, A. G., & Rajkovich, N. B. (2010). Addressing climate change in comfort standards. *Building and Environment*, 45(1), 18-22.
- Lee, Y.S. (2010). Office layout affecting privacy, interaction, and acoustic quality in LEED-certified buildings. *Building and Environment*, 45(7), 1594-1600.
- Levine, D., & Strube, M. J. (2012). Environmental attitudes, knowledge, intentions and behaviors among college students. *The Journal of Social Psychology*, 152(3), 308-326.
- Li, C., Hong, T., & Yan, D. (2014). An insight into actual energy use and its drivers in high-performance buildings. *Applied Energy*, 131, 394-410.
- Lindenberg, S., & Steg, L. (2007). Normative, gain and hedonic goal frames guiding environmental behavior. *Journal of Social issues*, 63(1), 117-137.
- Lo, A. Y., Chow, A. T., & Cheung, S. M. (2012). Significance of perceived social expectation and implications to conservation education: turtle conservation as a case study. *Environmental management*, 50(5), 900-913.
- Lockwood, C. (2006). Building the green way. *Harvard Business Review*.
- Maeda, H., & Hirose, Y. (2009). Expectation of empowerment as a determinant of citizen participation in waste management planning. *Japanese Psychological Research*, 51(1), 24-34.

- Major, A. M. (2000). Correlates of accuracy and inaccuracy in the perception of the climate of opinion for four environmental issues. *Journalism & Mass Communication Quarterly*, 77(2), 223-242.
- Mallawaarachchi, B. H., De Silva, M. L., & Rameezdeen, R. (2013). Importance of occupants' expectations for acceptance of green buildings: A literature review. In *Proceedings of the Second World Construction Symposium: Socio-Economic Sustainability in Construction*.
- Mankoff, J., Fussell, S. R., Dillahunt, T., Glaves, R., Grevet, C., Johnson, M., ... & Setlock, L. D. (2010). StepGreen. org: Increasing Energy Saving Behaviors via Social Networks. In *ICWSM*
- McCarty, J. A., & Shrum, L. J. (2001). The influence of individualism, collectivism, and locus of control on environmental beliefs and behavior. *Journal of Public Policy & Marketing*, 20(1), 93-104.
- McKenzie-Mohr, D. (2000). Fostering sustainable behavior through community-based social marketing. *American Psychologist*, 55(5), 531-537.
- Milfont, T.L. (2007). *Psychology of Environmental Attitudes: A cross-cultural study of their content and structure*. Doctoral Dissertation, The University of Auckland
- Milfont, T.L. & Gouveia, V.V. (2006). Time perspective and values: An exploratory study of their relations to environmental attitudes *Journal of Environmental Psychology*, 26, 72–82.

- Milfont, T. L., & Sibley, C. G. (2012). The big five personality traits and environmental engagement: Associations at the individual and societal level. *Journal of Environmental Psychology, 32*(2), 187-195.
- Moezzi, M., Gossard, M. H., & Lutzenhiser, L. (2002). Using mass media to influence energy consumption behavior: California's 2001 flex your power campaign as a case study. *Teaming for Efficiency: Human and social dimensions of energy use: understanding markets and demand, 8*, 15.
- Monroe, M. C. (2003). Two avenues for encouraging conservation behaviors. *Human Ecology Review, 10*(2), 113-125.
- Nickerson, R., & Moray, N. (1995). Environmental change. *Emerging needs and opportunities for human factors research, 158-176*.
- Nisbett, R. E., Peng, K., Choi, I., & Norenzayan, A. (2001). Culture and systems of thought: holistic versus analytic cognition. *Psychological review, 108*(2), 291.
- Nikolopoulou, M., & Steemers, K. (2003). Thermal comfort and psychological adaptation as a guide for designing urban spaces. *Energy and Buildings, 35*(1), 95-101.
- Nordlund, A.M., & Garvil, J. (2002). Value structures behind proenvironmental behavior. *Environment and Behavior, 34*(6), 740-756.
- Oreg, S., & Katz-Gerro, T. (2006). Predicting proenvironmental behavior cross-nationally values, the theory of planned behavior, and value-belief-norm theory. *Environment and Behavior, 38*(4), 462-483.

- Osbaldiston, R., & Schott, J. P. (2011). Environmental sustainability and behavioral science: Meta-analysis of pro-environmental behavior experiments. *Environment and Behavior*.
- Oskamp, S. (2007). Applying psychology to help save the world: Reflections on a career in psychology. *Analyses of Social Issues and Public Policy*, 7(1), 121-136.
- Oskamp, S., Harrington, M. J., Edwards, T. C., Sherwood, D. L., Okuda, S. M., & Swanson, D. C. (1991). Factors influencing household recycling behavior. *Environment and Behavior*, 23(4), 494-519.
- Paul, W. L., & Taylor, P. A. (2008). A comparison of occupant comfort and satisfaction between a green building and a conventional building. *Building and Environment*, 43(11), 1858-1870.
- Paz, M., Sellers, B. C., Fiore, S. M., & Richards, L. (2012). Integrating principles of environmental sustainability into human factors education: A recommendation. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 56, 1832-1836.
- Pelletier, L.G., Tuson, K., Green-Demers, I., Noels, K., & Beaton, A.M. (1998). Why are you doing things for the environment? A motivation toward the environment scale. *Journal of Applied Social Psychology*. 28 (5). 437-468.
- Petersen, J., Murray, M.E., Platt, G., and Shunturov, V. (2007). Using buildings to teach environmental stewardship: Real-time display of environmental performance as a mechanism for educating, motivating, and empowering the student body. In *Proceedings of Greening the Campus VI*. Retrieved November 20, 2014 from

<http://www.oberlin.edu/faculty/petersen/ColorPrint/Petersen2007BuildingsToTeachStewardship.pdf>.

Petty, R. E., & Cacioppo, J. T. (1986). *Communication and persuasion: Central and peripheral route to attitude change*. New York, New York: Springer.

Phillips, E., Sellers, B., & Fiore, S. M. (2010). Human centric environmentalism: Opportunities for the human factors community to contribute to global environmental solutions. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 54(11), 793-797.

Poortinga, W., Steg, L., & Vlek, C. (2003). Myths of Nature and Environmental Management Strategies. *People, Places, and Sustainability*, 16, 280.

Ries, R., Bilec, M. M., Gokhan, N. M., & Needy, K. L. (2006). The economic benefits of green buildings: a comprehensive case study. *The Engineering Economist*, 51(3), 259-295.

Ravindu, S., Rameezdeen, R., Zuo, J., Zhou, Z., & Chandratilake, R. (2014). Indoor environment quality of green buildings: Case study of a LEED platinum certified factory in a warm humid tropical climate. *Building and Environment*.

Robertson, S., & Walkington, H. (2009). Recycling and waste minimization behaviours of the transient student population in Oxford: results of an on-line survey. *Local Environment*, 14(4), 285-296

Roxas, B., & Lindsay, V. (2012). Social desirability bias in survey research on sustainable development in small firms: An exploratory analysis of survey mode effect. *Business Strategy and the Environment*, 21(4), 223-235.

- Ruano, M. A., & Cruzado, M. G. (2012). Use of education as social indicator in the assessment of sustainability throughout the life cycle of a building. *European Journal of Engineering Education, 37*(4), 416-425.
- Sampei, Y., & Aoyagi-Usui, M. (2009). Mass-media coverage, its influence on public awareness of climate-change issues, and implications for Japan's national campaign to reduce greenhouse gas emissions. *Global Environmental Change, 19*(2), 203-212.
- Scannell, L., & Gifford, R. (2013). The role of place attachment in receptivity to local and global climate change messages. *Environmental Behavior, 45*, 60-85.
- Scott, D., & Willits, F. K. (1994). Environmental attitudes and behavior a Pennsylvania survey. *Environment and Behavior, 26*(2), 239-260.
- Sellers, B. C., & Fiore, S. M. (2013). Sustainable and user-centered: Applying human factors solutions towards improving the effectiveness of "green" buildings. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 57*, 550-554.
- Sellers, B., Fiore, S., & Szalma, J. (2013). Developing a scale of environmental efficacy. *The International Journal of Sustainability Policy and Practice*.
- Singh, A., Syal, M., Grady, S. C., & Korkmaz, S. (2010). Effects of green buildings on employee health and productivity. *American Journal of Public Health, 100*(9), 1665-1668.
- Steg, L. & Vlek, C. (2009). Encouraging pro-environmental behavior: An integrative review and research agenda. *Journal of Environmental Psychology, 29*, 309-317.
- Stern, P. C. (2000). New environmental theories: toward a coherent theory of environmentally significant behavior. *Journal of Social Issues, 56*(3), 407-424.

- Stern, P. C., Aronson, E., Darley, J. M., Kempton, W., Hill, D. H., Hirst, E., & Wilbanks, T. J. (1987). Answering behavioral questions about energy efficiency in buildings. *Energy*, *12*(5), 339-353.
- Stokols, D., Misra, S., Runnerstrom, M. G., & Hipp, J. A. (2009). Psychology in an age of ecological crisis: from personal angst to collective action. *American Psychologist*, *64*(3), 181.
- Thatcher, A. (2013). Green ergonomics: definition and scope. *Ergonomics*, *56*(3), 389-398.
- Thompson, S.C.G. & Barton, M.A. (1994). Ecocentrism and anthropocentrism toward the environment. *Journal of Experimental Psychology*, *14*, 149-157.
- Tosi, F. (2012). Ergonomics and sustainability in the design of everyday use products. *Work: A Journal of Prevention, Assessment and Rehabilitation*, *41*, 3878-3882.
- Tuomey, J., CoStar Group. (2009). Personal Perspectives on LEED Management and Investment. *The Journal of Sustainable Research*, *1*(1), 245-254.
- U.S. Department of Energy. (n.d.) Better Buildings Challenge. Retrieved November 1, 2016 from <https://betterbuildingssolutioncenter.energy.gov/challenge>
- U.S. Energy Information Administration. (2015). *U.S. Energy-Related Carbon Dioxide Emissions, 2014*. Retrieved June 2, 2016 from <http://www.eia.gov/environment/emissions/carbon/>
- U.S. Environmental Protection Agency. (n.d.) Battle of the Buildings. Retrieved November 1, 2016 from <https://www.energystar.gov/buildings/about-us/how-can-we-help-you/communicate/energy-star-communications-toolkit/motivate-competition-0>

U.S. Green Building Council. Leadership in Energy and Environmental Design (n.d.) Retrieved December 5, 2013 from <http://www.usgbc.org/leed>

Von Paumgarten, P. (2003). The business case for high performance green buildings: Sustainability and its financial impact. *Journal of Facilities Management*, 2, 26-34.

Weaver, E. (2013, January 1). Green Building Sees Growth, But Fewer Firms Pursue LEED. *Building Green*. Retrieved November 15, 2013 from <http://www.buildinggreen.com/auth/article.cfm/2012/12/31/Green-Building-Sees-Growth-But-Fewer-Firms-Pursue-LEED/>

Weir, K. (2013). Design in Mind: Psychologists can help to design smart, sustainable spaces for the 21st century. *Monitor on Psychology*, 44(10), 51-53.

Wever, R., van Kuijk, J., & Boks, C. (2008). User-centred design for sustainable behaviour. *International Journal of Sustainable Engineering*, 1(1), 9-20.

Whitmarsh, L., & O'Neill, S. (2010). Green identity, green living? The role of pro-environmental self-identity in determining consistency across diverse pro-environmental behaviours. *Journal of Environmental Psychology*, 30(3), 305-314.

Xiong, Y., Krogmann, U., Mainelis, G., Rodenburg, L. A., & Andrews, C. J. (2015). Indoor air quality in green buildings: A case-study in a residential high-rise building in the northeastern United States. *Journal of Environmental Science and Health, Part A*, 50(3), 225-242.

Yates, S. M., & Aronson, E. (1983). A social psychological perspective on energy conservation in residential buildings. *American Psychologist*, 38(4), 435.

- Younger, M., Morrow-Almeida, H.R., Vindigni, S.M., & Dannenberg, A.L. (2005). The built environment, climate change, and health opportunities for co-benefits. *American Journal of Preventative Medicine*, 35 (5), 517-526.
- Yun, R., Lasternas, B., Aziz, A., Loftness, V., Scupelli, P., Rowe, A., Kothari, R., Marion, F., & Zhao, J. (2013). Toward the design of a dashboard to promote environmentally sustainable behavior among office workers. , Springer Berlin Heidelberg, Sydney, Australia, 246–252.
- Zhang, Y., & Altan, H. (2011). A comparison of the occupant comfort in a conventional high-rise office block and a contemporary environmentally-concerned building. *Building and Environment*, 46(2), 535-545
- Zhao, J., Lasternas, B., Lam, K. P., Yun, R., & Loftness, V. (2014). Occupant behavior and schedule modeling for building energy simulation through office appliance power consumption data mining. *Energy and Buildings*, 82, 341-355.
- Zink, K. J., & Fischer, K. (2013). Do we need sustainability as a new approach in human factors and ergonomics? *Ergonomics*, 56(3), 348-356.
- Zsóka, Á., Szerényi, Z. M., Széchy, A., & Kocsis, T. (2013). Greening due to environmental education? Environmental knowledge, attitudes, consumer behavior and everyday pro-environmental activities of Hungarian high school and university students. *Journal of Cleaner Production*, 48, 126-138.
- Zuo, J., & Zhao, Z. Y. (2014). Green building research—current status and future agenda: A review. *Renewable and Sustainable Energy Reviews*, 30, 271-281.

