Positive Sustainable Built Environments: The Cognitive and Behavioral Affordances of Environmentally Responsible Behavior in Green Residence Halls

by

Erin Miller Hamilton

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Doctoral Committee:

Professor Emerita Jean Wineman, Co-Chair
Associate Professor Raymond De Young, Co-Chair
Professor Robert Grese
Professor Linda Groat

Erin Miller Hamilton

emham@umich.edu

ORCID iD: 0000-0002-7487-4523

DEDICATION

For women who persist.

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ABSTRACT

A changing climate and global resource degradation have prompted technological innovations that reduce greenhouse gas emissions and are responsive to local ecological conditions. Green buildings that minimize the environmental impacts of the construction process and ongoing maintenance of the built environment, have been praised for their resource efficiency, design innovation, and benefits to building occupants. Increasingly, a growing body of literature has begun to examine the mutually beneficial relationships between sustainable architecture and building occupants. In addition to the well-documented benefits of inhabiting green buildings, the environmentally responsible behaviors (ERBs) of building occupants are worthy of examination. As a counterbalance to the dominant narrative in the green building industry that frames the building occupant as a potential energy liability, this research adopts a hopeful perspective on human behavior. Human behavior, though a significant contributor to global climate change, can also be part of the solution. This dissertation asserts that the situational context of green buildings may be designed to support the ERBs of building occupants.

Much of the current research examining occupant ERBs in green buildings has focused exclusively on educational buildings, or buildings designed with a pedagogical intent (e.g., schools, museums, libraries). Less is known about how occupants learn about issues of sustainability and adopt environmental behaviors in buildings that are not designed to teach. This dissertation focuses on the environmental behaviors emerging from the informal relationship

between undergraduate students and their on-campus residence halls, asking how the built environment supports or undermines the ERBs of occupants in green and non-green buildings over time.

This dissertation develops and tests a theoretical model for understanding how buildings may support occupant ERBs. The Positive Sustainable Built Environments (PSBE) model is composed of three principle domains: *Prime*, *Permit*, and *Invite*. Collectively, the three components of the PSBE model suggest that a building 1) may prepare occupants to participate in ERBs through the restoration of their mental resources and/or by communicating a sustainable ethos, 2) may allow building occupants to control aspects of the interior environment related to their own energy and resource consumption, and 3) may encourage occupants to engage in ERBs through building features that implement a variety of behavioral intervention strategies.

Occupant ERBs were measured over the course of one academic year through an online survey conducted with the first-time residents of six undergraduate residence halls. While many studies have explored the effectiveness of environmental behavior change intervention strategies with undergraduate students, very little research has examined the pre-existing psychological dimensions and the situational context of green buildings that may influence students' environmental behaviors.

The results of a linear mixed-effects regression analysis revealed no significant relationship between occupying a green residence hall and students' ERBs. However, a further analysis of specific building characteristics, analyzed according to the PSBE model, suggest strong support for two of the three domains. The *Prime* and *Invite* domains were found to positively support occupant ERBs, regardless of the greenness of the residence hall. Additionally, several personal characteristics (i.e., Biospheric values, Environmental Concern,

Technology motive, and Egoistic values) were found to significantly impact students' ERBs. Results are discussed in light of implications for designers seeking to harness the existing environmental inclinations of college students and to adapt the physical and informational environments of residence halls to better support environmentally responsible behavior.

CHAPTER I

Introduction

Amid growing awareness of the multiple origins of global environmental degradation, many industries have shifted their practices toward technological responses that minimize greenhouse gas emissions, curtail wasteful water practices, and source environmentally responsible materials. As such, the green building industry has grown dramatically in recent years, accounting for 40-48% of new non-residential construction and 60% of retrofits to existing building stock in 2015 (U.S. Green Building Council, 2015). Green building strategies seek to minimize the environmental impacts of the construction process and ongoing maintenance of the built environment, which otherwise contributes significantly to climate change and the world-wide destruction of natural resources. It is estimated that the built environment consumes over 70% of the electricity produced in the United States (U.S), contributing to almost 40% of the nation's total carbon dioxide emissions (U.S. Green Building Council, 2015).

However, the capacity of human behavior to address global sustainability challenges is also significant. The physical components of buildings, including the building envelope, HVAC and lighting systems are responsible for roughly 50% of the building's overall energy consumption, while variation in human behavior contributes the balance (Janda, 2011). In the U.S. alone, it has been estimated that changes in a few daily behaviors (e.g., reducing personal travel by automobile, lowering thermostats in the winter, and line-drying one's clothes) could add up to an overall reduction of greenhouse gas emissions by 20% over the next ten years

(Dietz, Gardner, Gilligan, Stern, & Vandenbergh, 2009). Thus, individual behaviors spread over multiple contexts can contribute significantly to the improvement of global environmental health.

One appropriate context in which to study the cultivation of environmentally responsible behavior (ERB) is the built environment, as Americans spend about 90% of their time indoors (EPA, 2009). As such, green buildings provide the unique potential for occupants to engage with environmental issues and to be exposed to building features that use energy and resources responsibly. In green buildings, it is not uncommon for educational signage to publicize the merits of sustainable design – highlighting the design process, efficient fixtures, and choice of eco-friendly finishes. However, presently, little is known about the effects of environmental education and awareness of green building features on occupant ERBs. This dissertation seeks to explore the psychological and contextual factors that influence occupant ERBs in undergraduate residence halls and the effect of inhabiting a green building on the long-term evolution of occupant ERBs.

Green Buildings and Behavior: Three Perspectives in the Literature

With the expansion of the green building industry, literature examining the intersection of humans and green buildings has emerged. The scope of the existing literature can be divided into three domains, each characterized by the primary beneficiary of the person-building relationship. The first domain adopts a *building-centric* perspective, which examines how the environmental performance of sustainable buildings is impacted by trends in occupant behavior. The predominant message communicated in this literature depicts the building occupant in a negative light, as an impediment to achieving the projected energy efficiency of the building (Browne & Frame, 1999; Hong, Taylor-Lange, D'Oca, Yan, & Corgnati, 2016; Langevin, Wen, & Gurian, 2015; Masoso & Grobler, 2010; Yu, Fung, Haghighat, Yoshino, & Morofsky, 2011). Applications of this research domain seek to develop training materials, policies, and building management strategies to improve the building's environmental performance given the anticipated negative impacts caused by occupant behavior (Khashe et al., 2015; Masoso & Grobler, 2010; Steinberg, Patchan, Schunn, & Landis, 2009).

A second substantial body of literature offers a *person-centric perspective*, which examines the predominantly positive effects on occupants of inhabiting green buildings. The primary documented benefits include increasing occupant awareness and concerns about indoor air quality, lighting quality, thermal comfort, acoustic quality, and degree of privacy (Benfield, Rainbolt, Bell, & Donovan, 2015; Hua, Göçer, & Göçer, 2014; Kelz, Evans, & Röderer, 2015; Lennon, Douglas, & Scott, 2017; Paul & Taylor, 2008; Thatcher & Milner, 2016). Additionally, secondary effects are documented that show how occupant awareness and concern subsequently impact job satisfaction, productivity, and employee absenteeism; these secondary effects are of substantial interest to employers (Guerin, Kim, Brigham, Choi, & Scott, 2011; Issa, Rankin, Attalla, & Christian, 2011; MacNaughton et al., 2017; McCunn & Gifford, 2012; Thatcher & Milner, 2016).

Bridging the building- and person-centric approaches in the literature is the third domain of this literature, described as a *co-benefits perspective*. This research posits that green buildings and occupants may interact in a symbiotic relationship, where green buildings provide a number of benefits (as previously described), but also behavioral and cognitive support for ERBs. In return, behaviors cultivated in green buildings may positively impact the environmental performance of the building itself and also develop into behavioral patterns that will emerge across time and in other physical and social contexts.

Research using the *co-benefits perspective* addresses the educational and behavioral implications of occupying formal green educational environments such as libraries, museums, and school buildings (Aulisio, 2013; Barnes, 2012; L. B. Cole, 2015; L. B. Cole & Altenburger, 2017; Han & Hyun, 2017; Higgs & McMillan, 2006; Izadpanahi, Elkadi, & Tucker, 2017). This research has predominately paired the physical context of the educational setting with a structured, building-specific environmental curriculum. This pairing offers a new conduit of formal environmental education, adding to the existing use of socio-cultural (e.g., role models, school culture, governance) and personal factors (e.g., pre-existing values, outside experiences) (L. B. Cole, 2015; L. B. Cole & Altenburger, 2017; Higgs & McMillan, 2006). However, the assumed need to pair the setting with a specific curriculum is worth further examination. This dissertation adds to this growing body of literature an exploration of how green buildings may informally support occupant ERBs, without the necessity of a specific, structured environmental or green building curriculum.

Dissertation Overview

This dissertation employs a mixed-methods approach, consisting of an online survey and building analysis, to investigate the phenomenon of environmentally responsible behavior within the context of green and conventional university residence halls. The research questions explored herein address the psychological and contextual dimensions of undergraduate ERBs in on-campus residence halls and the differences between occupant ERBs within green and conventional residence halls over time, seeking to identify specific characteristics of buildings that either support or hinder the performance of environmentally responsible behaviors. This study is notable for the absence of specific, structured environmental or green building curricula associated with the buildings studied, focusing rather on the informal means of translating environmental messages to building occupants. The study includes six undergraduate residence halls on two university campuses in the Midwest region of the United States. These settings are described in greater detail in later chapters; a brief overview is provided here. Of the three residence halls per campus, two halls are *green*[1] and one hall is *conventional*.

Psychological Dimensions of ERB

New undergraduate residents of each residence hall were surveyed at two points in time during the 2016-2017 academic year. The first survey instrument was distributed during the third week of the fall semester and the second survey instrument was distributed roughly five months later, mid-way through the spring semester. The online survey instrument included self-report measures of ERB in the categories of energy, water, materials, and travel. Students also responded to a series of items intended to capture their overall values, motivations, knowledge about climate change, and awareness of green building features. Linear mixed-effects regression analyses of the data from the fall and spring semesters reveal multiple drivers of ERBs across green and conventional residence halls.

Contextual Dimensions of ERB

The contextual dimensions of students' ERBs are explored at two levels. The broad effect of living in a green versus a conventional residence hall on occupant ERBs is explored in conjunction with the psychological dimensions within the linear mixed-effects regression models described previously. At a more fine-grained level, researcher coding and analysis of building

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1 In this dissertation, a green building is one that meets the criteria or is officially certified at the LEED® Gold level. LEED®, Leadership in Energy and Environmental Design, is a program developed by the U.S. Green Building Council that certifies new buildings and renovations according to several metrics of sustainable design.

features illuminates a deeper understanding of the characteristics of residence halls that affect occupant ERBs, regardless of the greenness of the building.

Organization of the Dissertation

The chapters presented in this dissertation contribute to the theoretical and empirical body of knowledge on the conditions that support environmentally responsible behavior and translate these findings to outcomes useable by designers of sustainable buildings (see Figure I.1).

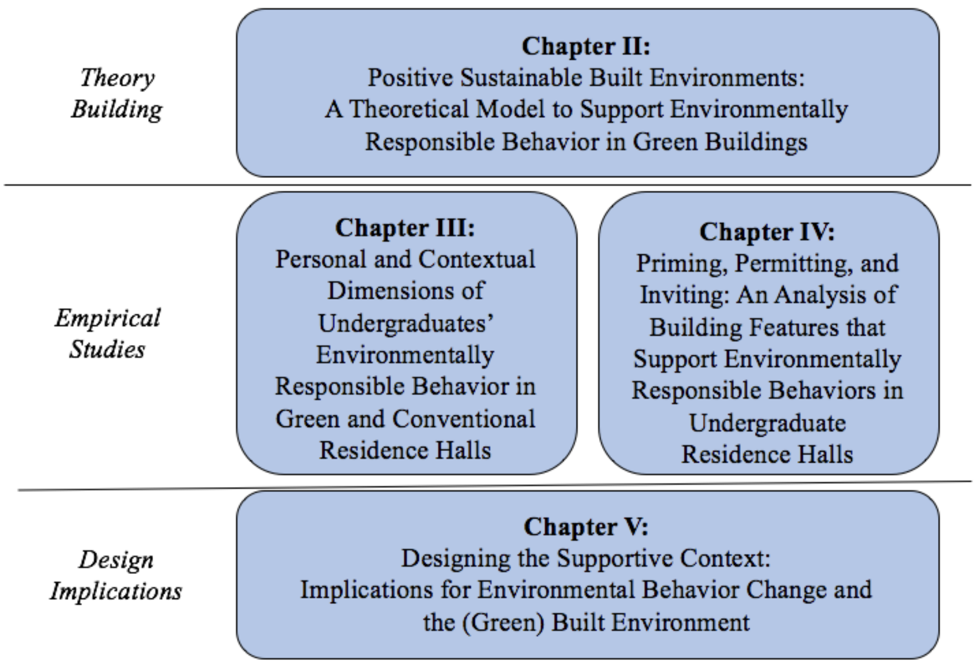

Figure I.1. Dissertation Organization

Chapter II begins with a discussion of environmental education in green buildings, highlighting that while the current literature adequately addresses the outcomes of occupant environmental awareness and knowledge of green building features, it lacks an empirical connection to environmentally responsible behavior. Situating green buildings within the literature on behavioral affordances, Chapter II presents a theoretical model for conceptualizing the supportiveness of buildings for cultivating occupant ERBs. The Positive Sustainable Built Environments Model posits that ERBs may be afforded in green buildings via three characteristics: 3) features that *prime* ERB through cognitive preparation, like education or attentional restoration, 2) features that *permit* occupants to participate in ERB, and 3) features that *invite* occupants to participate in ERB through a variety of behavioral interventions available in the built environment.

Chapter III begins with a review of the literature pertaining to undergraduate ERBs in university residence halls. This review notes two key limitations: 1) the majority of the research is based on time-limited formal behavioral interventions that ignore the informal role of the residence hall itself on occupant ERBs, and 2) few research studies address students' existing psychological characteristics that support or undermine their participation in ERBs. Chapter III presents the results of a longitudinal study with undergraduate students living in six green and conventional residence halls at two Midwestern universities. The data were analyzed using linear mixed effects regression and suggest several trends across residence halls about the characteristics that predict ERBs of undergraduate students.

Given that previous research has yet to establish a clear relationship between the relative greenness of residence halls and occupant ERBs, Chapter IV closely examines the features of the buildings included in the study. This chapter applies the Positive Sustainable Built Environments model to quantify and analyze the supportiveness of each of the residence halls along three dimensions: 1) Prime, 2) Permit, and 3) Invite. Each dimension was operationalized and used to evaluate photographs documenting the range of public, semi-public/private, and private spaces available to undergraduate residents of the buildings. The resulting scores were incorporated into a regression analysis to identify relationships among the model dimensions and occupant ERBs. Implications for the design of environments to support ERB are discussed.

Chapter V presents an overview of the psychological and contextual factors that contribute to occupant ERBs in undergraduate residence halls. The chapter suggests ways of further refining the Positive Sustainable Built Environments model and for using the model in future empirical research. The chapter concludes with implications for practitioners to design green buildings that support the growth and durability of occupant ERBs, both within and beyond the green building context.

Significance

This dissertation contributes to both theory-building and pragmatic outcomes. In examining how green built environments afford ERB, this project bridges architectural and psychological disciplinary approaches to environmental stewardship. Traditional architectural approaches to sustainability generally are confined to technological strategies that aim to increase energy and resource efficiency, while often lamenting the negative impact of human behavior on building performance. Psychological approaches largely focus on changing specific behaviors, rather than creating *supportive* environments in which a wide suite of meaningful environmental behaviors may flourish. The Positive Sustainable Built Environments model presented herein provides a means for conceptualizing and analyzing the potential supportiveness of built environments for the cultivation of ERBs.

While there is an emerging body of research exploring some of the educational and behavioral outcomes of inhabiting green built environments, there is scant empirical research that specifically investigates the inherent psychological dimensions of undergraduate students'

ERBs. This research contributes to the knowledge of the antecedents of ERB with important implications for more effectively supporting ERBs within the specific population of undergraduate students.

Lastly, this dissertation translates theory into practice by examining the physical features of the built environment that afford and encourage environmentally responsible behavior. Although residence halls are typically experienced only briefly in one's life, this unique building typology houses many of the functions that non-students experience in daily life: including residential areas, places for work, and third places. Thus, the implications of this work may provide insight regarding the design of other public and private spaces. In this endeavor, this research aims to challenge designers in their thinking about green design – to recognize the potential for impacting sustainability outcomes by promoting human behavior that will extend beyond the experience within any particular green building.

CHAPTER II

Positive Sustainable Built Environments: A Theoretical Model to Support Environmentally Responsible Behavior in Green Buildings

Amid increasing urgency to respond to the environmental demands of a disrupted climate, the resource-intensive building industry has seen a prolific expansion of sustainable building practices, including environmentally responsible construction, sourcing of materials, and the long-term operations and maintenance of energy and resource efficient "green" buildings (Jones & Mandyck, 2016). With the growth of this industry has emerged a substantial and growing body of research on the intersections of green buildings and human occupants. Research in this area typically adopts a *building-centric perspective* (i.e., how occupant behavior affects the performance of buildings), a *person-centric perspective* (i.e., the social and psychological benefits of inhabiting green buildings), or *a co-benefits perspective* (i.e., how green buildings may serve as supportive contexts for environmental education in three-dimensional space). Adopting a *co-benefits perspective*, this chapter will review the emerging literature on environmental education in green buildings, the psychology underlying environmental behaviors, and present a theoretical framework for analyzing the affordances of environmentally responsible behavior in green buildings.

Environmental Education in Green Buildings

Recent research frames green buildings as potential teaching tools for communicating environmental information and for providing contextual support for occupant adoption of environmentally responsible behaviors (ERBs). Behaviors cultivated in green buildings have the potential to not only positively impact environmental performance in the present setting, but also, to coalesce into behavioral patterns that are translatable across time and contexts as occupants move among various environments. Known as *spillover*, the notion that behaviors in one setting can support the adoption of the same or related behaviors in another setting is an intriguing topic among current empirical studies because of the potential to amplify the positive impact of pro-environmental behaviors (Margetts & Kashima, 2017; Truelove, Carrico, Weber, Raimi, & Vandenbergh, 2014; Whitmarsh & O'Neill, 2010).

The educational and behavioral implications of occupying green buildings have been explored within commercial settings (Littleford, Ryley, & Firth, 2014; McCunn & Gifford, 2012), but more commonly within educational environments, like libraries (Aulisio, 2013; Barnes, 2012), museums (Sutton & Wylie, 2013), and more recently, school buildings (L. B. Cole, 2014, 2015; L. B. Cole & Altenburger, 2017; Higgs & McMillan, 2006; Izadpanahi et al., 2017; Kostic, Stankovic, & Tanic, 2015). Researchers conceptualize the physical context of the school building as one channel of environmental education, in addition to other socio-cultural (e.g., role models, school culture, and governance) and personal factors (e.g., pre-existing values and outside experiences) that individually and collectively predict students' environmental attitudes, green building knowledge, and ERBs at school (L. B. Cole, 2015; L. B. Cole & Altenburger, 2017; Higgs & McMillan, 2006).

As a channel of environmental education, the current literature substantiates the role of the physical context to support environmentally responsible behavior. Cole's (2015) study of middle school students in *Teaching Green Buildings* found that students' ERBs at school were significantly predicted by their appraisal of their school setting as a supportive environment for environmentalism (L. B. Cole, 2015). In Cole's study, environmental support was operationalized as social support within the environment (i.e., students' acknowledgement of teacher and peer support in performing environmental behaviors), as well as physical support within the environment (i.e., opportunities within the school building to act and learn about the environment). While affirming the social and physical support for students' ERBs derived from the green school building, these conclusions merit further inquiry to identify how specific features of green buildings support environmental behaviors and to clarify the relationship between environmental learning and ERBs in green buildings.

Affording Behavior in Green Buildings

Gibson's (1979) ecological theory of perception and affordances provides a useful foundation for theorizing the green building as a situational context that either supports or hinders occupant environmentally responsible behavior. It is unnecessary to provide a comprehensive summary of the history and theory of affordances as this has been executed well elsewhere (Maier, Fadel, & Battisto, 2009). However, a broad understanding of the evolution of thought around this term gives shape to the present argument that there is a theoretical precedent for exploring how green buildings support *behavior* specifically, in addition to learning about environmental issues and becoming aware of green building features.

There is debate about the extent to which Gibson intended to convey that objects in the built environment inherently contain perceptible affordances independent of current human needs, the definition of affordances is nonetheless rooted in their ability to engage with human behavior within a specific ecological context. Gibson describes Lewin's interpretation of the term *aufforderungscharakter*, or the "invitation character" of a feature (James J. Gibson, 2015, p. 130), indicating that features in the built environment may draw a person into engagement. Following Gibson, Norman (1988) later elaborates that a perceived affordance "is the result of the mental interpretation of a thing and the perceived properties which determine its possible *use* [emphasis by author]" (S. R. Wu et al., 2017, p. 86). Maier and colleagues describe Artifact-User-Affordances as a communication of *behavioral* information, wherein "the affordances indicate what behaviors are possible, whether or not they are ever expressed" (Maier et al., 2009, p. 398). In this capacity, affordances are defined as building features that allow for user action and are often expressed as "X-able" (e.g., walk-able, lean-able, sit-able)(Maier et al., 2009).

However, recent research in the context of green buildings has framed affordances not as features that indicate possible user behaviors, but as elements that merely *communicate* sustainability to building occupants. Wu et al. define green building affordances as sustainable features that are "aware-able," "know-able," and "perceive-able" (2017, p. 88). In a departure from previous definitions linking affordances in the built environment specifically to behavior, Wu et al. seemingly conflate awareness of sustainable features with ERB. Based on the knowledge-deficit assumption in environmental education (Ramsey & Rickson, 1976), the implication of this research suggests that increasing awareness of green building features and environmental issues will produce positive changes in environmental behavior. However, as will be discussed shortly, the predictive relationship between knowledge and behavior is tenuous.

Taken together, the current research on environmental education and behavioral affordances in green buildings does not provide a clear means to identify features in the built environment that support ERB. Consequently, current empirical studies lack truly practical applications for the design field to positively impact occupant environmental behaviors through evidence-based design of green buildings. Further, behavioral scientists are unable to meaningfully assess the effectiveness of green buildings as collections of behavior change interventions. Thus, new theoretical and empirical research is needed to connect the insights from environmental education, human cognition and the environment, and the psychology of behavioral change to articulate the rich and varied means through which built environments may support ERB.

Psycho-social Variables and Behavior

Multiple disciplines have investigated the effectiveness of several strategies to change human behavior through the targeted appeal to one or more psycho-social variables that shape human behavior. While located in fields as diverse as health care, social work, business, and environmental studies, many of the assumptions of the underlying models of behavior are similar.

A common initial approach to changing behavior is to provide information about the nature of an issue and its related consequences. A deficiency in adequate knowledge is often assumed to underlie behavior deemed risky or harmful to oneself, others, or environment. Information campaigns that promote awareness of the negative environmental consequences of certain behaviors are launched with the assumption that an increase in awareness will promote concern (or positive attitudes) about the issue, and subsequently, will result in a change in behavior (Ramsey & Rickson, 1976). These assumptions are frequently manifested in green building features[2] that aim to educate building occupants about the negative environmental impacts from the built environment and how green building features have been implemented to mitigate these effects (see Figure II.1).

Figure II.1. Educational Signage Describes Green Building Features
Left: Educational signage in the Dana Building at the University of Michigan describes the building renovation which added space vertically to minimize impact on the surrounding campus landscape; Middle: Interactive signage explains water consumption of traditional and water-efficient bathroom fixtures; Right: Natural lighting minimizes use of artificial lighting. [Photos by author.]

Yet despite being deeply rooted in environmental education theory, changing knowledge and attitudes is a fairly weak means of changing behavior alone. Much empirical evidence supports the claim that increased knowledge is rarely sufficient to produce changes in behavior

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2 Incorporating environmental and green building educational features into the building design is awarded credit toward LEED® (Leadership in Energy and Environmental Design) certification. Launched by the United States Green Building Council, LEED® is one of the most ubiquitous green building certification programs used worldwide. Building projects are awarded credits in main content areas: sustainable sites; location and transportation; energy and atmosphere; water efficiency, materials and resources; indoor environmental quality, innovation in design; and credits pertaining to regional priorities (U.S. Green Building Council, 2016).

(Hungerford & Volk, 1990). Comparably, attitude change (often posited to follow a change in awareness) is also unreliable to support lasting changes in behavior, in part because attitudes tend to be easily swayed by the availability of new information and experiences. Further, cultivating ERB through attitudinal change is also problematic because people frequently do not act in alignment with their stated attitudes (Hines, Hungerford, & Tomera, 1987).

However, despite the likelihood that awareness and attitudes alone are not likely to produce durable behavior change, they are still valid predictors of behavior when considered among an array of other variables. The extensive literature of the psychology of environmental stewardship identifies a number of constructs that, when considered together, can change behavior. These include packages of psychological (e.g., attitudes/beliefs, values, locus of control, accountability, personal norms, willingness to take action), cognitive (e.g., declarative knowledge, procedural knowledge, mental clarity), and socio-cultural factors.(Ajzen, 1991; Ajzen & Fishbein, 1980; Hines et al., 1987; Stephen Kaplan & Kaplan, 2009; Schwartz, 1977a; Stern, 2000).

Situational Context and Behavior

Less clearly defined is a package of variables referred to as the "situational context." Few formal models of behavior explicitly include the situational context, or the setting in which behavior takes place (Hines et al., 1987; Stephen Kaplan, 1991). The situational context may be defined as a collection of variables beyond a person's control - policies, economic conditions, and other aspects of the built and natural environments - that may support or hinder environmentally responsible behavior (F. G. Kaiser, 1996). Its absence in several prolifically researched behavior models (Ajzen, 1991; Ajzen & Fishbein, 1980; Schwartz, 1977a; Stern,

2000) suggests that the situational context may be viewed as irrelevant in many behavior change interventions. Educational initiatives that principally seek to shift awareness and attitudes often do so without regard for the situational context in which behavior occurs[3].

However, much of behavior is ingrained in the context in which it was developed and altering patterns of behavior often requires some degree of addressing the situational context. Habitual behavior develops over time in response to recurring stimuli in the environment, including physical characteristics, social, and time cues, that activate certain behavioral responses. The habit discontinuity hypothesis suggests that when a change in situational context disrupts a recurring pattern of behavior, it opens an opportunity to shift one's behavior; the absence of the familiar context and rote behavioral response prompts deliberate consideration of one's actions (Verplanken, Walker, Davis, & Jurasek, 2008). Verplanken et al. found that environmentally concerned university employees who had recently relocated were significantly more likely to consider adopting environmentally responsible travel mode choices than environmentally concerned employees who had not recently moved. A change in context therefore supported a shift to adopting sustainable behaviors.

Another version of changing the situational context to support specific behaviors is to identify and remove barriers in the environment to facilitate desired behavior. Recent work in the psychology of behavior change has popularized the term *nudge* in reference to "interventions that steer people in a particular direction while preserving their freedom of choice" (Hertwig &

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3 Note: Contemplative practices (e.g. deep breathing, meditation, reflection) serve as interventions, or techniques, that can be employed without regard for the situational context. By internally supporting individual behavior change, these techniques facilitate coping with an external situational context that is undesirable. As these practices are implemented within the internal realm of the individual mind, they are easily portable across multiple situational contexts.

Grüne-Yanoff, 2017, p. 973). A common application of the behavioral nudge is the default behavioral option regarding organ donation. In this case, the situational context is altered to nudge people toward participation in the program. While retaining the choice to opt out of the program, behavior is steered in a particular direction. Thus, the nudge removes barriers in the situational context due to lack of awareness about the program or perceived difficulty regarding the alternative action of opting-in to the organ donation program. Through seamlessly altering the situational context of the decision to enroll in the organ donation registry, the default option bypasses many of the contextual barriers to the desired behavior and possibly remains undetected. Although nudging in this case may produce the desired results, nudging policy interventions are weak with respect to transferability, or their ability to foster positive spillover behaviors. In situations where it is not necessary for people to cognitively engage with their behavioral choices, the likelihood for positive behaviors to translate to other situational contexts is low.

In the interventions reviewed thus far, undesirable (environmental) behaviors have been framed as emerging from some sort of deficit: not enough knowledge, lacking favorable attitudes or awareness, or difficulty overcoming situational constraints to perform the desired behavior. An alternate perspective of the situational context with respect to ERB adopts a more optimistic view of human motivations and behavior. The Reasonable Person Model (RPM) proposes the conditions underlying a supportive context for desirable behavior to emerge (Basu & Kaplan, 2015; Stephen Kaplan & Kaplan, 2009). While not an intervention strategy per se, the model provides a framework from which to approach designing physical, informational, and social environments that will be supportive of ERB. Based on principles from cognitive psychology about human beings' universal information processing needs, the RPM is made up of three interconnected domains: model building, being effective, and meaningful action.

Model building refers to the human need for information – to understand and explore the world. Environments that provide information that is organized and legible, as well as vast and diverse, are compatible with innate human needs to make sense of and learn more about the people and places around us (Rachel Kaplan & Kaplan, 1989b).

Being effective refers to a state of mental clarity defined by the ability to focus, plan for the future, accurately assess one's own competence, and inhibit undesirable behavior. This fluctuating state of clarity is affected by ongoing interactions between two types of attention. Involuntary attention, or fascination, is effortless and brings our attention to objects and events that have evolutionarily benefitted human survival (e.g. loud noises, food, water, danger, pleasure). In contrast, directed attention requires effort to inhibit fascinating stimuli in the environment and remain focused (James, 1892). Unfortunately, the capacity to direct attention fatigues from overuse and this has important ramifications for ERB (Hartig, Kaiser, Strumse, & Bowler, 2007). In addition to exhibiting irritability and highly distracted behavior, a mentally fatigued person is less capable of inhibiting impulsive behavior, becomes more oriented to short-term goals, and may also be less likely to engage in helping behaviors (S. Kaplan, 1995). In contrast, a person with restored mental capacity exhibits a clarity of mind that permits effective functioning, the ability to plan ahead, to consider the longer-term consequences of behavior, and to think about others (S. Kaplan & Berman, 2010). Clarity of mind aids social and behavioral effectiveness, supports the building of new understandings of pro-environmental behavior, and provides the capacity to seek out meaningful opportunities for participation.

Lastly, *meaningful action* refers to the innate human need to apply one's knowledge and skills to actions that have value. Being able to participate in actions that allow for the testing and evaluation of one's mental models, or understandings, of the world aids further knowledge development and provides on-going assessment of one's competence to respond to the demands of a given situational context. Participation is necessary as repeated experience is critical to build knowledge and skills, or competencies, that are transferrable to other situational contexts.

Recently, researchers have focused on the development of knowledge and skills; new contributions to the notion of behavioral *nudging* suggests another set of non-coercive strategies called *boosting* that may support long-term behavior change (Hertwig & Grüne-Yanoff, 2017). *Boosting,* which emphasizes the support of existing human competences, overlaps conceptually with the information-processing rationale underlying the Reasonable Person Model. Rather than seeking to subvert or bypass the situational context of behavior, *boosting* relies on the transparent alteration of the environment. Hertwig and Grüne-Yanoff state, "competences are often best fostered by redesigning aspects of individuals' external environment or by teaching them how to redesign them" (2017, p. 980). Thus, boosts have a key advantage over nudges; by changing the situational context to allow people to make use of their knowledge and skills, boosts strengthen competence, which is transferrable to other settings.

Durability of behavior over time is also likely heightened with boosts because building competence has the added benefit of being intrinsically satisfying (De Young, 1996). Positive emotions associated with internal sources of satisfaction have been shown to support long-term ERB in the form of volunteerism with environmental stewardship activities (Grese, Kaplan, Ryan, & Buxton, 2000; Ryan, Kaplan, & Grese, 2001), and an overall broadened capacity for environmental awareness, identifying needed behavioral responses, and care for others (Fredrickson, 1998).

A graphic depiction of the role of situational context with respect to behavior change interventions is shown in a portion of Figure II.2. The model presented in the remainder of this chapter frames green buildings as active contexts and supportive environments for the emergence of occupant ERBs. This perspective is also reflected in Figure II.2 and later, as the Positive Sustainable Built Environments model in Figure II.11.

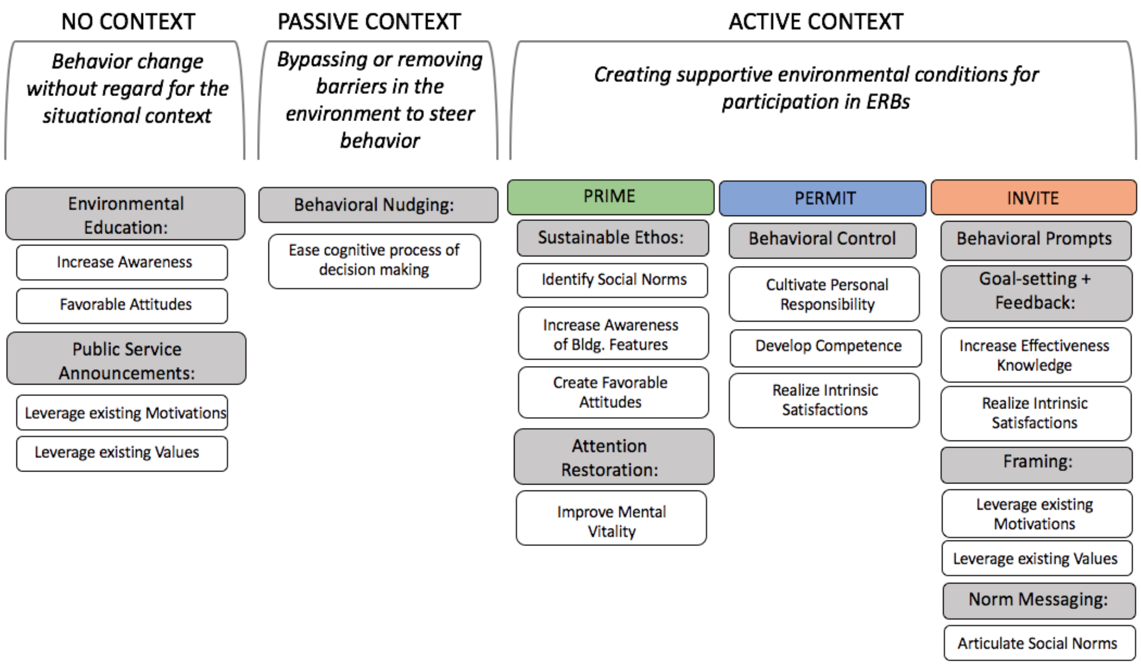

Figure II.2. The Role of Situational Context in Behavior Change Interventions
This diagram summarizes the role of the situational context in traditional behavior change interventions. Behavior change strategies are presented in the grey boxes, with the principal target variables listed beneath in white. The three categories indicated by the colored boxes under "Active Context" comprise the three domains of the Positive Sustainable Built Environments Model that will be presented in the remainder of this chapter.

Positive Environments and Behavior

A newly emerging area of scholarship within the field of positive psychology explores person-environment relations in order to explain issues of psychological growth, intrinsic satisfaction, and sustainable behavior (Corral-Verdugo & Frías-Armenta, 2015). *Positive* *environments* are defined as ones that provide benefits—psychological, physical and otherwise—to inhabitants. A benefit "implies the immediate use of a resource or the satisfaction of a need" (2015, p. 2). As such, the benefits derived from occupying green buildings have been well-documented (MacNaughton et al., 2017; Magzamen et al., 2017; Thatcher & Milner, 2016). Specifically, occupants reap the rewards of healthy indoor air quality, comfortable lighting, thermal comfort, and acoustical characteristics.

Recently, Corral-Verdugo and Frias-Armenta (2015) suggest positive environments not only provide benefits, but *elicit* positive behavior in return. In a positive environment, the benefits occupying a green building is reciprocated as the environment also affords—and even *invites*—occupant participation in maintaining the environment in the present and sustaining resources for the future. A positive environment is thus defined as "the context that provides individual and collective benefits, also influencing human actions to conserve the present and future sociophysical milieu" (Corral-Verdugo & Frías-Armenta, 2015, p. 2). Within the context of the present research, *Positive Sustainable Built Environments* are defined as environments built with the intention to use resources (e.g., energy, water, materials) responsibly, provide healthy physical and social environments for occupants, and to positively influence occupant performance of environmentally responsible behaviors both in the present and the future.

The Positive Sustainable Built Environments Model

Taken together, the scholarship reviewed thus far represents a spectrum of techniques that differ with respect to the role of the situational context in supporting behavior change. The positive environment perspective provides a significant expansion to how researchers and designers may think about green built environments and occupant behavior in both a contextual-temporal sense and with regard to considerations of how behavior is promoted. Positive sustainable built environments (PSBE) should support ERB both in the present and in the future, and both within and beyond the current green building context. In addition to supporting knowledge acquisition through communication about environmental issues and green building features, PSBE would also elicit ERB through the above-mentioned more traditional behavior change pathways that include a variety of psycho-social variables and active use of the situational context. However, the PSBE model more adequately reflects the current state of empirical research on the cultivation of ERB, namely that behavior change is more likely to occur, be durable, and spillover if it is targeted via multiple psychological channels and through a variety of intervention techniques (Abrahamse, Steg, Vlek, & Rothengatter, 2005; De Young, 2000).

The theoretical framework proposed in this chapter is composed of three thematic areas that encompass and add to the existing literature to describe how green buildings can be designed to allow, support, and encourage environmentally responsible behavior. The first domain consists of building features or qualities that support, or *Prime,* the likelihood that occupants will participate in environmentally responsible behavior. The second domain describes the extent to which the building allows, or *Permits,* occupants to participate in stewardship behaviors. The third domain describes how environments may encourage, or *Invite,* building occupants to adopt environmentally responsible behaviors via calls to action or built competencies.

Environments that Prime

The first category in the PSBE model examines opportunities for the design of green buildings to prime building occupants to participate in ERB. Priming is a means of preparing an occupant for action and relates to how the physical context of the green building creates the conditions in which building occupants may be receptive to adopting new or continuing previously established ERBs. Priming behavior in green buildings includes: 1) communicating a building-wide sustainable ethos through the communication of positive social norms about sustainability and sharing information about environmental issues and sustainable building features, and 2) cultivating mental states conducive to participating in ERBs.

Communicating a Sustainable Ethos

The notion that buildings communicate to users and shape behavior is not a novel one. Researchers have long suggested that buildings provide a "medium of nonverbal communication" (Cranz, Lindsay, Morhayim, & Lin, 2014). Even more explicitly, David Orr (1997) refers to the underestimated "hidden curriculum" of buildings to powerfully influence environmental education and behavior. Orr laments the underutilized pedagogy of architecture, that in its failure to intentionally communicate the built environment's connection to nature, ultimately teaches the opposite:

> It is said tacitly throughout the entire building. … Nowhere in the building do students learn about the materials used in its construction or who was downwind or downstream from the wells, mines, forests and manufacturing facilities where those materials originated or where they eventually will be discarded. And the lesson learned is mindlessness; it teaches that disconnectedness is normal. (p. 597)

Cranz, et al. (2014) suggest easily recognizable features that communicate an "ethos of sustainability" are necessary to cultivate a material and experiential connection to the outside world; Coleman refers to this process as "normalizing sustainability" for the general public (Coleman, 2016).

Recent literature has examined the behavioral outcomes of occupant awareness of the green features within buildings. Khashe et al. investigated the influence of green branding, specifically LEED® certification, on occupants' pro-environmental behaviors in a simulation study using immersive virtual environment technology. Participants exposed to the LEED® branding were significantly more likely than a control group to execute two pro-environmental behaviors: choosing to use natural instead of electric lighting for a task and correctly disposing of recyclable paper (Khashe et al., 2015). Similarly, in an observation study of food disposal behavior, researchers Wu and colleagues report significant differences in pro-environmental food disposal behavior (i.e., composting versus trash disposal) in a sustainable building versus a conventional building, even after accounting for participant environmental attitudes and values. These researchers suggest that the message of sustainability embodied in the green building may have contributed to the behavioral differences, much the same way that priming-based interventions promote ERB (D. W.-L. Wu, DiGiacomo, & Kingstone, 2013).

Many green buildings seek to educate occupants in ways that range from passive techniques (e.g., presenting information about the building) to more active features that give occupants information about what they can do to participate in the building's sustainability goals. While the provision of information alone is minimally effective to directly increase ERB, increased knowledge may interact with a number of psycho-social variables to support behavior change.

Kaiser and Fuhrer (2003) identify three important types of knowledge that assist the understanding of stewardship issues: declarative, procedural, and effectiveness knowledge. Declarative knowledge involves creating awareness of the environmental issue by defining the problem. In green buildings, educational displays often convey information about how the building has been designed to function sustainably. Figure II.3 shows an example of a simple educational display, in this case informing occupants about the LEED® features of the building.

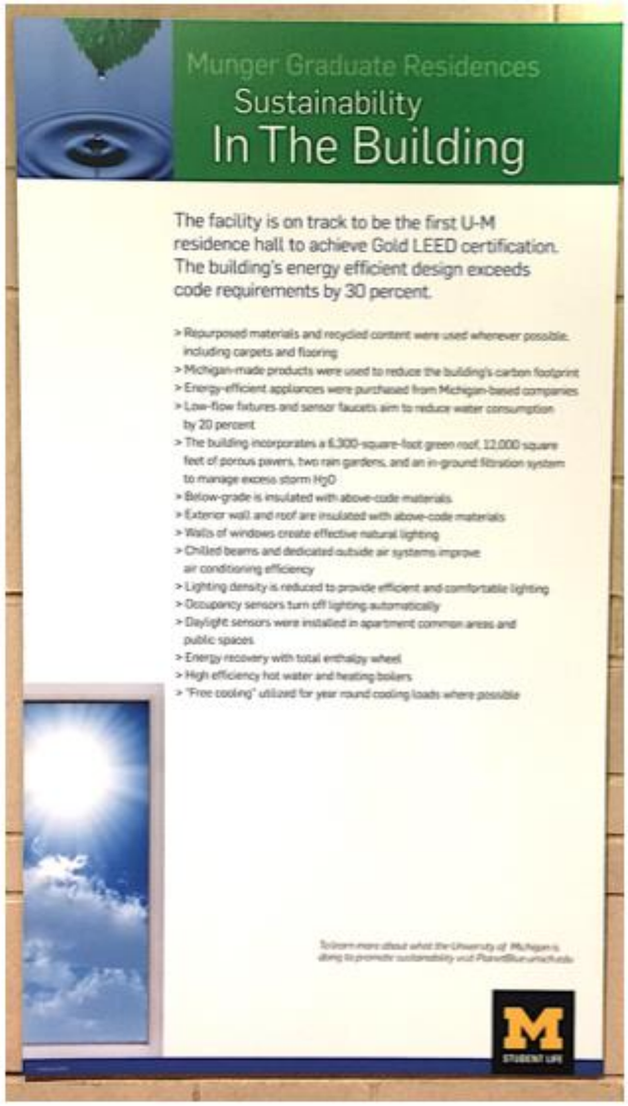

Figure II.3. Informational Signage Explains Sustainable Building Features
Educational Signage in Munger Graduate Residence Hall at the University of Michigan hangs in the lobby of the building. As the campus' first residence hall to achieve LEED® Gold certification, Munger provides a unique opportunity to highlight sustainable building features. [Photo by author.]

However, informational interventions that focus solely on declarative knowledge generally result in increased levels of knowledge, but little else (Abrahamse et al., 2005). People require different forms of knowledge as they move from understanding the nature of a problem to deciding to enact a behavioral response (Pelletier & Sharp, 2008). Declarative information conveyed through educational features often must be accompanied by procedural information about how to achieve a particular conservation goal or effectiveness knowledge about the degree of efficacy each behavior holds for impacting environmental change (F. G. Kaiser & Fuhrer, 2003). Figure II.4 demonstrates the communication of procedural knowledge via instructions regarding how to conserve water using a dual-flush toilet. Effectiveness knowledge could further be cultivated if this message expressed how much water is saved with each water-minimizing flush.

Figure II.4. Operating Instructions for Dual-Flush Toilet
A small placard explains the appropriate direction to push the flush lever of a dual-flush toilet. [Photo by author.]

Despite the consensus that human environmental behaviors may be influenced by messages of sustainability within green buildings, there is little consensus about what this looks like in practice. The term *green aesthetics* is contentious and often dismissed as too prescriptive and limiting by architects and designers (Cranz et al., 2014, p. 831). However, the intention of green aesthetics is one where ecological sustainability and inspiring beauty co-exist. While there are only a few attempts to articulate features of a design aesthetic that communicate sustainability, initial theoretical work has proposed some of the following characteristics:

- An organic sensibility interdependent with regional and local landscape features;
- Sustainable materials and technologies relevant to location;
- The celebration of variety in design and composition, as would occur in nature;
- The use of local and found materials relevant to place;
- An apparent connection between human and environmental needs (Cooke, 2012).

Still, translating these and other guidelines into building features observable by occupants and developing a method for evaluating the extent to which a green aesthetic is communicated in a built environment require future empirical research.

Cultivating Mental States Conducive to ERB

The ability to be intentional and considerate of long-term goals over short-term benefits requires a considerable amount of forethought and focus. These cognitive activities require a condition called mental vitality, or *being effective,* from the RPM. Thus, priming the mind to participate in ERB includes supporting individuals in maintaining the capacity to consider the unintended consequences of one's behavior; to choose more environmentally responsible, though possibly less convenient behaviors; and to be receptive to adopting new ERBs. Cultivating mental states conducive to ERB requires that the built environment provide opportunities for people to achieve mental restoration[4].

Environments that permit the resting of directed attention have been termed *restorative* (R. Kaplan & Kaplan, 1989; S. Kaplan, 1995). Nature is a frequently cited component of restorative environments, as elements of nature tend to be effortlessly engaging and provide an alternative experience from one's daily life. Research in environmental psychology has linked restorative environments with increased ecologically-friendly behavior through the mental vitality and self-regulation associated with restored directed attention capacity (De Young, 2010; Hartig, Kaiser, & Strumse, 2007; S. Kaplan & Berman, 2010).

Green buildings may support environmentally responsible behavior by providing building occupants a variety of contexts in which to restore their mental capacity in the presence of nature. Empirical research has demonstrated that even nature enjoyed briefly—micro-restorative experiences such as the view out a window (Figure II.5)—are beneficial for reviving a tired mind (R. Kaplan, 2001; Tennessen & Cimprich, 1995).

4 The built environment should also not increase the mental burden on occupants, such that it becomes a source of mental fatigue.

Figure II.5. Views to Nature Afford Opportunities for Mental Restoration
Left: A study room inside a residence hall overlooks the green roof and the changing fall colors along the lake; Right: A wall of windows in a lounge within a different residence hall provides a panoramic view of campus greenery. [Photos by author.]

Fortunately, many green buildings already provide abundant opportunities to connect visually to the outside world due to the increased focus on incorporating natural daylighting in green building interiors. However, green buildings can easily increase micro-restorative experiences by ensuring that window views are enhanced via natural elements and by natural landscaping of the exterior of the building.

In addition to providing views of nature through windows, built environments may provide both visual and physical access to nature both in and around the building by bringing nature indoors or creating areas for people to walk around the building exterior. Even small-scale nature such as indoor plants have been shown to improve attentional capacity in interior environments (Evensen, Raanaas, Hagerhall, Johansson, & Patil, 2013). Combined with the physical health benefits of periodic walking throughout the workday, interior and exterior walking paths (Figure II.6) that bring people into contact with nature offer the enhanced benefit of supporting mental clarity.

Figure II.6. Walking Paths Around University Residence Halls
Top: Walking paths outside of one residence hall surround students with trees; Bottom Left: A meandering stone path weaves students around sculptural objects and affords wide-open views of the sky; Bottom Right: A side walk alongside native plantings creates visual interest outside another residence hall. [Photos by author.]

Environments that Permit

As part of a theoretical model of how buildings may support occupant adoption of environmentally responsible behavior, it is necessary to address the degree to which occupants are provided with the *ability* to participate in ERBs by a green building. Do green buildings afford occupants the opportunity to conserve energy by turning off unnecessary lights and adjusting the thermostat, or are these functions beyond the realm of occupant control? Increasingly, the issue of automation in green buildings intersects with the extent to which occupants may exercise habitual behaviors of energy and resource conservation that they may already conduct in other settings.

A common techno-centric approach to minimize disruption in the energy performance of a green building is to diminish, as much as possible, the degree to which occupants can directly influence the energy performance of the building they inhabit. Publications in trade industry journals such as REHVA (Federation of European Heating, Ventilation and Air Conditioning Associations) suggest that building automation is a "necessary instrument for maintaining the energy-efficient operation of buildings through continuous energy and building management" (M. Becker & Knoll, 2014, p. 46). However, building systems designed to bypass occupant involvement in the control of energy usage and comfort provisioning are likely to produce two undesirable outcomes: 1) they are less satisfying to occupants, and 2) they are ultimately, less energy efficient.

In a study investigating occupant attitudes towards green issues and satisfaction in a green building, researchers found that occupants in more highly automated, less user-engaging, environments were more dissatisfied with their buildings due to the lack of control they were afforded (Monfared & Sharples, 2011). In this scenario, one can imagine dissatisfaction being especially problematic if the occupants are aware that the building is designed to be sustainable and yet they experience discomfort. Research has also shown that, in addition to allowing dissatisfaction to fester amongst building occupants, increasing building automation (and minimizing occupant control) actually undermines occupants' stewardship behaviors within the building (Murtagh, Gatersleben, Cowen, & Uzzell, 2015), resulting in decreased energy efficiency outcomes. A recent study of a high performing green building notes, "Unlike conventional buildings, [the green building] takes over and facilitates many of the conservation functions that would be otherwise be expected from successful behavior change in a building" (Coleman, 2016, p. 290). The capacity of the built environment to control energy and resource consumption relative to the building occupant will naturally result in unpredictable behavioral patterns depending on other personal and socio-cultural factors influencing ERB. Nevertheless, should automation in green buildings replace the need for occupants to monitor and manage their own behavior, the likelihood for positive spillover of ERBs in the green building to other settings will be curtailed.

The complicated issue of automation versus occupant agency is receiving attention in the building industry. Following the 2009 conference for Passive and Low-Energy Architecture, Cole, Brown & McKay (2010) released *Building Human Agency: a timely manifesto.* Critically examining the spectrum in sustainable building design from automation to active occupant engagement, the manifesto suggests, "a dynamic and responsible interaction between inhabitants and architecture can lead to important energy and carbon reductions" (2010, p. 343). As previously discussed, research on the behavioral motivations for participating in environmental conservation has found intrinsic satisfactions (De Young, 2000) and the motivation to continue impactful work (Ryan et al., 2001) can emerge as a result of direct participation even when other motives (e.g., for social interaction) initially prompted the behavior. This merits consideration with respect to how building occupants are permitted to participate in the energy and resource conservation in their buildings, as pro-environmental behaviors developed in a single green building setting may spillover to other settings.

Future empirical research is needed to determine the appropriate balance between automated resource efficiency systems and systems permitting occupants to control the environmental conditions of green buildings. However, it is likely these determinations will need to be largely context dependent based on local regional climate priorities and resource restrictions.

Environments that Invite

The third component of the Positive Sustainable Built Environment model draws from the literature of environmental stewardship in which empirical research has examined a number of strategies to promote and elicit behavior change at the individual and community level. Behavioral interventions that appeal to a wide variety of psycho-social variables through multiple strategies are more likely to affect behavioral change (Abrahamse et al., 2005); similarly, the quantity and diversity of behavioral intervention features in green buildings are hypothesized to support ERB. The following represent a range of strategies that might be employed in green buildings:

Behavioral Prompts

Prompts are simple signals from the environment that cue a quick behavioral response (e.g., a reminder above the light switch to turn off the lights when leaving the room). Effective prompts are easily noticeable and located at the point where a decision about behavior must be made (Aronson & O'Leary, 1983). While prompts may effectively elicit immediate behavior, their simplicity assumes the desired behavior is one that is easily understood and performed. Further, the effectiveness of a prompt may diminish over time as people familiarize with its presence, unless the cued action develops into a habitual behavior or the prompt changes to recapture people's attention.

Goal-setting and Feedback

For green building occupants, feedback about personal energy and resource consumption contributes to ongoing learning about actions that work to reduce consumption. The success of feedback in changing behavior largely depends on the specificity and frequency of the feedback. Feedback must be offered at least monthly in order to be minimally effective, although best practices suggest daily or real-time feedback produce the greatest reductions in energy consumption, especially when combined with other behavioral affordances like procedural information about ways to lower energy use (Abrahamse et al., 2005; Brandon & Lewis, 1999; Staats, Harland, & Wilke, 2004). In a study of residential energy use, direct feedback linked to specific behaviors (e.g., appliance usage, lighting, heating/cooling) resulted in the highest energy reductions (Darby, 2000). Figure II.7 shows an example of an energy dashboard, a type of feedback mechanism, that might be found in a green building.

Figure II.7. Energy Dashboard
Energy dashboards are increasingly being implemented in green buildings to provide occupants ongoing feedback about their energy consumption. This example shows the additional behavior change strategy of social competition by making public the energy use of several campus buildings. [Photo obtained from Bowdoin.edu ("Gauging Real-Time Energy Use Among Campus Buildings," 2010).]

The tangible effects realized through feedback systems allow occupants to build, test, and redefine their mental models, assisting them in reaching their goals. Testing the combined effect of feedback and goal-setting, Becker (1978), asked 40 families to set a difficult energy conservation goal of 20% and 40 families to set an easy goal of 2%. Within each of these groups, half of the families received feedback (three times per week) and half only received feedback at the end of the intervention. (Twenty families served as a control group who only received information about energy conservation). The combined effect of feedback and goal-setting was supported, as only the 20% goal combined with the feedback condition statistically differed from the control group in energy conservation.

Framing: Explicit Value and Motivation Messaging

It is a common misconception that people who engage in environmentally responsible behaviors are singularly motivated by environmental, or biospheric, values. Rather, a number of significant value orientations and motivations can be compatible with conservation behavior change. In addition to biospheric values, Stern (2000) also identifies social (i.e., care for others' wellbeing) and egoistic (i.e., self-interest) values as able to promote ERBs. Similarly, participants in a range of environmental stewardship programs report motivations for participation beyond environmental concern, including developing a sense of belonging and expanding personal learning (Bramston, Pretty, & Zammit, 2010). While messages about environmental issues or green building features are often framed to communicate their relative importance via environmental values, diversifying the framing may serve to communicate to a wider audience of green building occupants (see Figure II.8).

Normative Communication

In addition to the larger organizational norms that may be communicated via the green aesthetics of the building, social norms emerge at the intersection of people and the environment. Lawson (2001) suggests it is not our relationships directly with spaces or buildings, but our relationships with other people mediated through space, that matter most. Thus, it is perhaps surprising that people underestimate the degree to which their behavior is influenced by social norms (Nolan, Schultz, Cialdini, Goldstein, & Griskevicius, 2008).

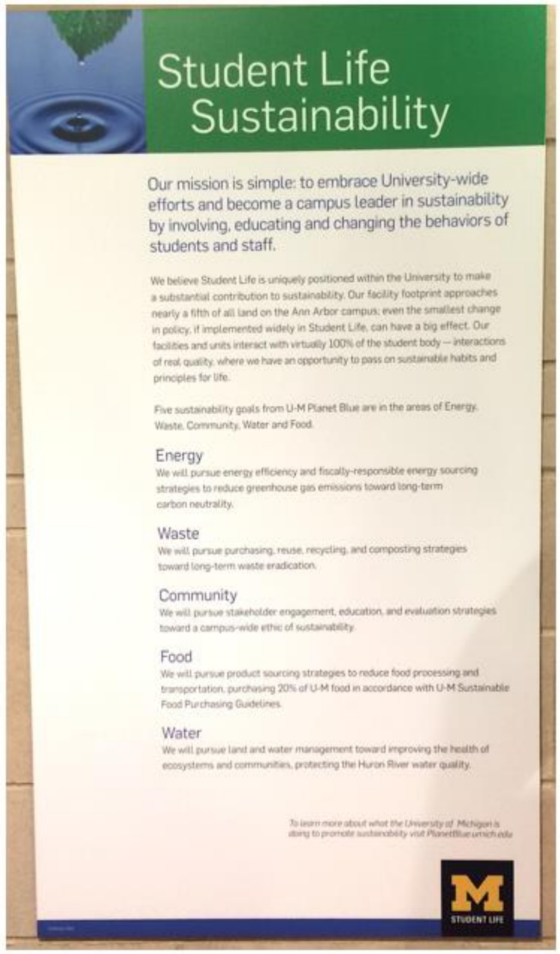

Figure II.8. Predominant Information Framing: Environmental Values
Educational signage in the lobby of Munger Graduate Residence Hall at the University of Michigan describes the sectors of student life that intersect with sustainability. The narrative emphasizes the environmental value of the described practices but could diversify the message by explaining how these actions are beneficial to the community and to individual students. [Photo by author.]

Physical and visual accessibility is important to the communication of social norms for behavior as the ways in which people encounter and move through space shape their "access to information and ideas" (Wineman & Peponis, 2010, p. 90). Thus, while often not explicit, the social norms in an environment are usually easily understood by the observation of people and their interactions with others and objects in the built environment. Through these interactions people are able to develop an understanding of what is expected in a new social situation or physical setting. In particular, the spatial configuration of the built environment facilitates the emergence of social norms by defining the potential field of "encounter and co-presence" (Hillier, Burdett, Peponis, & Penn, 1987; Peponis & Wineman, 2002) available to building occupants. Through the arrangement of paths, nodes of activity and physical barriers, the arrangement of space permits the experience of encountering others and specific green building features through available patterns of movement (Hillier, Penn, Hanson, Grajewski, & Xu, 1993; Peponis & Wineman, 2002). While observable individual and group behaviors may explicitly communicate social norms for behavior, design features in a built environment similarly convey information about the shared values foregrounding the design decisions in a building (e.g., green aesthetics communicating a sustainable ethos).

Highlighting social norms by amplifying others' environmentally responsible behavior is another technique for conveying norm-based information that assists people in developing mental models of ERBs (McMakin, Malone, & Lundgren, 2002). Buildings may facilitate the communication of social norms by making points of interaction between people and the building salient. For instance, locating environmental controls in public, socially-connected places, allows environmentally engaged building users to serve as models of behavior for others. Other examples include centrally located and easily seen trash, recycling, and composting receptacles (Figure II.9).

Figure II.9. Waste Disposal Receptacles
Trash and recycling bins at a public university in the Midwest are prominently located in every room. Featuring bright colors and educational labels, bins are easily noticeable and disposal instructions for different kinds of materials are clearly communicated. [Photo by author.]

Social norm messaging can be explicitly communicated via post-hoc signage that aligns the expressed or implied injunctive norm (i.e., the suggested or required action) with the descriptive norm (i.e., what other building users commonly do). Katsev and Mishima (1992) found providing feedback to college students regarding pounds of collected recycling effectively supported ongoing recycling behavior by demonstrating the efficacy of students' actions. But this posted feedback was also effective because it publicized the injunctive norm promoting recycling with the descriptive norm that students in a particular residence hall were quickly adopting recycling habits. Normative messages can additionally be amplified by binding them to a valued social reference group (e.g., school identity, company name). (See Figure II.10.)

Figure II.10. Social Normative Communication About Composting Behavior
Signage on the compost bins located throughout a residence hall promote university-wide social norms around conservation and diverting waste from landfills through the slogan "We conserve." [Photo by author.]

Anticipated Behavioral Responses

The theoretical framework underlying the Positive Sustainable Built Environments Model is a proposed tool for analyzing the potential supportiveness of a green built environment for cultivating environmentally responsible behaviors. Represented in three-dimensional space, the model consists of three axes: Prime, Permit, and Invite (see Figure II.11).

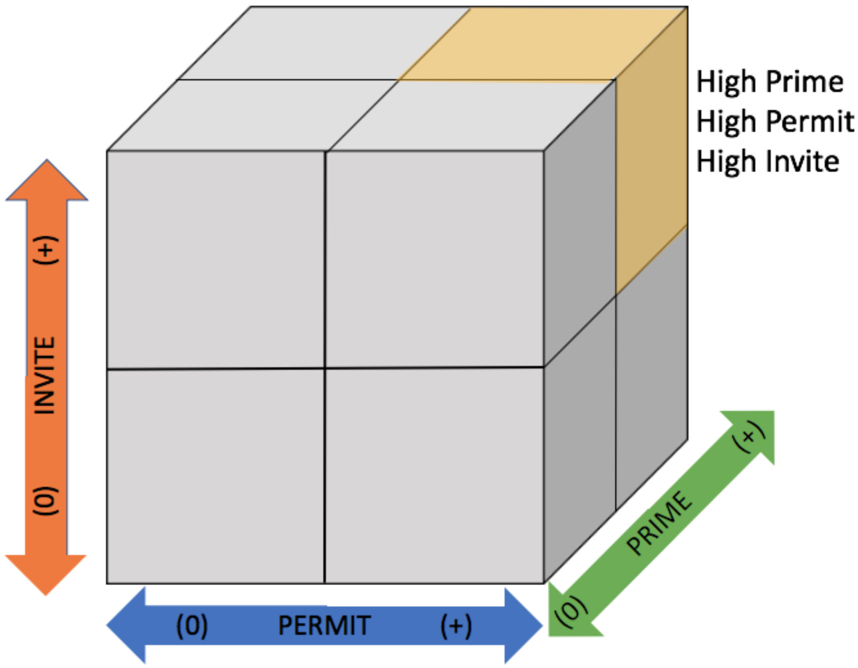

Figure II.11. The Positive Sustainable Built Environments Model – Hypothesized Interactions
The Positive Sustainable Built Environments Model is composed of three domains: Prime, Permit, and Invite. An environment that highly primes, permits, and invites environmentally responsible behaviors is hypothesized to be supportive of occupant ERBs.

The assessment of a (green) building would involve the analysis of the building on each of the three axes. A simple analysis on each axis would produce a low-high dyad, which collectively would result in eight combinations of values across the three axes. A supportive environment for ERB is thus hypothesized to 1) highly *prime* occupants to adopt ERBs via communication of a sustainable ethos, opportunities for attention restoration, and access to foundational knowledge, 2) highly *permit* occupant participation in the energy and resource conservation within the building, and 3) highly *invite* occupants to engage in ERB by appealing to multiple psycho-social predictors of behavior and a variety of behavioral intervention strategies. Drawing from the empirical literature included in this chapter on the behavioral responses of humans to these conditions, we can make the following hypotheses about the environmental behaviors of occupants in buildings with these sets of characteristics. For brevity, this section will discuss the anticipated behavioral outcomes of occupants in four of the sets of characteristics that represent conditions that would exist between the extremes (neither all high nor all low) of the model.

- *High Prime/Low Permit/Low Invite*: In an environment that is evidently sustainable through natural finishes and materials, access to natural views, and an abundance of natural light, occupants who are not provided any controls of the environmental conditions of their surroundings and who are not encouraged to personally take part in conservation behaviors will potentially adopt a passive stance in relation to the environmentalism in the building. There may be the sense that "the building is green, so I don't have to be." Previously habitual ERBs may falter in this setting if there are not opportunities to continue performing the behaviors.
- *High Prime/Low Permit/High Invite*: An environment that conveys sustainable design throughout, actively promotes behaviors and choices that are environmentally responsible, but provides little to no opportunities for occupants to actually engage with these behaviors within the building may elicit feelings of disappointment or frustration when occupants reflect on the limited scope of behaviors afforded to them in their current environment. However, occupants may simultaneously be inspired or encouraged to seek out opportunities to engage in impactful behavior in other situational contexts.
- *Low Prime/High Permit/Low Invite*: In a building that does not appear to be sustainable and in which there are no cues in the environment to promote ERB, occupants afforded a high degree of control over their environmental conditions will likely continue

performing ERBs that they already habitually perform in other contexts, so long as the social norms in this environment do not deter these behaviors.

- *Low Prime/High Permit/High Invite*: This building does not communicate sustainability in its finishes, furnishings, or opportunities to connect to nature, however it does afford occupants a high degree of control over their environmental conditions and the amount of energy and resources they consume. Efforts to promote energy and resource conservation within the building are likely propagated by the occupants themselves, visible in reminders to turn off lights and properly dispose of waste. There is an entrepreneurial spirit in actions taken to be environmentally responsible in this building that is not or does not appear to be sustainable.

Conclusion

Recent research has explored the educational and behavioral outcomes of inhabiting sustainable buildings. However, the predominant measures assess awareness of green building features and knowledge of green building systems in an attempt to predict changes in environmental attitudes and behaviors in green buildings. Given that knowledge and attitudes alone are generally insufficient to produce behavioral change, it is necessary to expand how we look at sustainable buildings to incorporate a more widely accepted range of personal and socio-cultural variables that influence behavior. Further, it is necessary to actively incorporate the role of the situational context as a factor contributing to ERB in green buildings. The Positive Sustainable Built Environments model presented herein combines knowledge from the psychology of environmental stewardship and environment and behavior studies into a cohesive model for theorizing sustainable buildings and their potential impact on occupant environmental behaviors.

The theoretical model proposed in this chapter is not intended as a comprehensive determinant of human behavior. Rather, when considered collectively, the elements of this model present a pragmatic perspective of the physical context's contribution to supporting environmental education and behavior in sustainable buildings. Broady (1972) describes this probabilistic perspective: "The physical form is only a *potential* environment since it simply provides possibilities or clues for social behavior. The effective - or total - environment is the product of this physical pattern plus the behavior of the people who use them, and that will vary according to their social background and their way of life" (p. 181). Behavioral outcomes in sustainable buildings may be further influenced by additional layers of intersecting personal and socio-cultural factors, such as pre-existing values, motivations, prior experiences, and other programmatic or formalized instruction implemented within the physical context.

The validity of this model for predicting actual behavioral responses remains an empirical issue for future research. However, if buildings can achieve energy and resource savings while also promoting occupant knowledge acquisition, cognitive capacities, and behavioral responses that may extend beyond the single green building context, the mitigative and adaptive effects of sustainable building strategies could be much more far-reaching than currently conceived.

CHAPTER III

Personal and Contextual Dimensions of Undergraduates' Environmentally Responsible Behavior in Green and Conventional Residence Halls

Institutions of higher education in the United States emit more than 50,000 metric tons of carbon dioxide annually (Sinha, Schew, Sawant, Kolwaite, & Strode, 2010). Student and faculty travel, infrastructure, and information technology systems contribute to such a significant carbon footprint that some researchers have suggested transitioning institutions of higher education to online platforms in order to bypass the need for campus buildings and travel (Versteijlen, Perez Salgado, Janssen Groesbeek, & Counotte, 2017). Thus, initiatives to reduce carbon emissions and conserve resources have gained momentum on college campuses. As such, researchers and practitioners have begun to explore the relationships among cultures of sustainability on university campuses with students' environmentally responsible behavior (ERB). ERBs refer to the many public and private ways individuals may participate in environmental activism, efficiency, or conservation behaviors in an effort to minimize one's immediate and long-term effects on the environment (Stern, 2000; Watson, Johnson, Hegtvedt, & Parris, 2015).

College students, in particular, are a unique population in which to study ERB as their transition to a new situational context parallels their emerging independence to define their values and beliefs that may (or may not) differ from their family and context of origin. At this moment of malleability, the power of the situational context, in which new college students begin to define their values and intentions for the future, is potentially heightened in its capacity to steer students toward responsible environmental behaviors (Whitley, Takahashi, Zwickle, Besley, & Lertpratchya, 2018). After all, early college students are often living on college campuses, which are increasingly adopting institutional and curricular commitments to sustainability that permeate many aspects of the contemporary college experience. At the institutional level, almost 500 colleges and universities across all 50 states have signed the Presidents' Climate Leadership Commitments, pledging and tracking their progress toward reaching carbon neutrality (Second Nature, n.d.). Further, three out of four institutes of higher education have at least one campus office or center devoted to "sustainability" and student fees allocated to funding green projects on campus have sharply risen (Perrault & Clark, 2018).

At the curricular level, researchers have defined sustainability learning outcomes to assess undergraduate students' environmental knowledge and reasoning across the curriculum (Brodrick Hartman, DeMars, Peckham Griscom, & Martin Butner, 2017). Adopting an interdisciplinary approach to teaching sustainability, faculty at Northern Arizona University invite students to complete a "Resource Consumption and Waste Audit" of their behavior, which can be used as the foundation for assignments in many disciplines (Savageau, 2013).

At the structural level, most new construction on college campuses must now meet minimum sustainability requirements, often equivalent to LEED® standards, if not officially certified ("Trends in Campus Architecture and Planning," 2012). Taken together, this network of intersecting institutional, pedagogical, and structural sustainability initiatives has been described as a "whole-system approach to sustainability" (Whitley et al., 2018, p. 245), and the life of the on-campus college student is deeply embedded within this system.

This chapter will examine the interaction that occurs over time between college students and one part of the whole-system approach to sustainability on university campuses – the green residence hall. Despite the growing prevalence of sustainability initiatives among university campuses broadly, there still remains relatively little published research on promoting ERBs in these settings. What does exist focuses almost exclusively on explicit behavior change interventions that often fail to consider the college student's existing inclinations to participate in ERBs. This chapter will first provide an overview of formal environmental behavior change strategies in residence halls and then present a study conducted on the psychological antecedents of college students' ERBs. This study explores the role of sustainable buildings to support the growth of ERBs over time. The chapter will conclude with a discussion of the on-campus residence hall as a potential supportive context for the cultivation of and on-going commitment to ERBs and will suggest ways to craft the physical environment to better support the ERBs of college students.

Formal Environmental Behavior Change in Residence Halls

Much of the published research on environmental behavior in residence halls investigates the effectiveness of specific strategies and/or technologies to change behavior. These strategies may be employed in green or conventional residence halls over a defined period of time, in which researchers record and measure behavior change relative to a pre-intervention baseline.

The most prevalently documented behavior change strategy is a form of information-provisioning called feedback. Where basic information campaigns seek to change behavior by filling a gap in knowledge about the causes or the detrimental effects of an environmental problem, feedback is a type of information that is specific to individual or group behavior. As such, providing feedback to building occupants specifically about their own behavior, helps people to build awareness of how their actions result in environmental consequences. The most effective feedback for reducing residential energy consumption is characterized by its frequency (daily and real-time is more useful than monthly); specificity (appliance-specific is better than household); and understandability (must be easily interpretable with a mixture of text and graphic communication) (Darby, 2000; Fischer, 2008; Karjalainen, 2011; Steg & Vlek, 2009). Methods of providing feedback in residence halls range from the hand-crafted (displaying the weekly weight of collected recycled materials on a poster board in a common room) to the tech-savvy (widescreen monitors with scrolling energy consumption data updated in real-time) (Katsev & Mishima, 1992; Ma, Lin, Li, & Zhou, 2017; Parece, Younos, Grossman, & Geller, 2013; Petersen, Shunturov, Janda, Platt, & Weinberger, 2007; Wisecup, Grady, Roth, & Stephens, 2017). The effectiveness of providing feedback to college students in residence halls mirrors results found in other populations – feedback is an effective tool for reducing energy and water consumption when connected with the goal to conserve resources by changing behavior.

In the empirical literature on ERBs in residence halls, feedback strategies are often combined with other techniques to induce changes in behavior. Frequently, researchers provide feedback about behavior and create social competition among multiple residence halls or groups of students within a single residence hall (Delmas & Lessem, 2014) by enticing behavior with a reward, or incentive, for the greatest behavior change at the end of the competition or intervention period (Petersen et al., 2007; Sintov, Dux, Tran, & Orosz, 2016). Feedback has also been combined with social support in the form of peer "eco-reps" who aid in interpreting feedback and support group-based behavioral responses to improve resource conservation in residence halls (Bloodhart, Swim, & Zawadzki, 2013).

The current body of research on college student ERB in on-campus residence halls is limited in three ways. First, formal behavior interventions often ignore any existing psychological inclinations that students bring to the residence hall setting. Additionally, formal behavior interventions do not adequately mimic the conditions of every day experience in a residence hall. Lastly, the conclusions from research on ERBs in residence halls often fail to address the long-term durability of the behavioral effects produced by formal intervention strategies. The next section will address each of these limitations.

Gaps in Formal Environmental Behavior Change Approaches

Among the limitations of the current literature on promoting ERBs in university residence halls is the underlying assumption about what motivates humans' behavior, and college students' in particular. Overwhelmingly, researchers suggest that residents of dormitories are not motivated to reduce their overall consumption of resources because they bear no financial responsibility for their consumption. One study suggests, "University students who live in residential halls typically have little or no incentive to moderate behaviors such as electricity usage, because the amount they pay is not directly influenced by how much they use" (Bekker et al., 2010, p. 327). While residents of on-campus housing do not pay for their resource consumption the way most people do through monthly utility bills, it is an incomplete summation of human motivation to assume people would not be otherwise motivated to conserve resources. Undergraduate students in residence halls may have compatible values, derived satisfactions, or previously developed understandings about the consequences of their actions that are compatible with conservation behavior. Yet presently, few research studies have sought to illuminate the existing characteristics that undergraduate students bring with them to their residence halls that shape their environmental behaviors. Perrault and Clark's (2018) thematic analyses of qualitative responses to a survey of college students about their reasons for performing sustainable behaviors revealed a variety of motivating factors beyond financial savings, including sense of responsibility, social influence, and the desire to benefit the environment. Thus, students' values and motivations for conservation behavior that expand beyond self-concern, merit further study.

A second gap in the literature on promoting ERB in college residence halls is the inauthenticity of experimental (or quasi-experimental) interventions. The majority of human behavior simply is not situated within the context of a formal behavior change intervention. As is common in this body of research, the particular conditions of social competition during a defined treatment period may prove effective for inspiring a swift speed of change, however every day behavior, outside the confines of an incentivized battle to conserve, will likely not be characterized by the same quality of focus and dedication. The initial novelty of social competition will likely fade as students habituate to the game and as they tire of being vigilant enough to win the incentive. In one feedback and competition study, researchers found that feedback strategies were ineffective for changing attitudes and behaviors for students who were not actively engaged in the competition and who did not express an intention to reduce their energy consumption. However, the feedback technology was useful for an unintended audience – facility staff found the energy consumption information helpful for detecting improper building performance (Timm & Deal, 2016). This study highlights the importance of connecting feedback mechanisms with relevant and meaningful goals; the information provided via feedback technology helps to inform decisions about necessary behavioral adaptations that will help people to reach their goals (Abrahamse, Steg, Vlek, & Rothengatter, 2007; L. J. Becker, 1978; McCalley & Midden, 2002).

Similarly, few studies have considered the context of the building itself as a type of behavioral support, without active intervention by researchers. Orr describes the supporting role of the built environment in fostering ERB and conveying information about environmental issues as the "hidden curriculum" of green buildings (Orr, 1993, 1997). A few studies have begun to address the hidden curriculum of sustainability education in green residence halls (Watson et al., 2015):

> Universities may afford students with the opportunity to live in green dorms, thus creating daily encounters with features such as dual grey water toilets, automatic lights, and sustainable building materials as well as participating in green programming. The experience of 'living green' represents manifestations of university sustainability policies. Presumably, such mere exposure[5] through living on-campus in green dorms may enhance the likelihood that students will engage in ERBs. (Watson et al., 2015, p. 3)

Initial studies that have begun to examine the informal relationship between the physical context of green buildings and occupant environmental behaviors (without the direct intervention by researchers to change behavior) have returned mixed results. One study suggests that in comparison to conventional residence halls, green buildings support increased occupant ERBs (Watson et al., 2015). However, a more recent longitudinal study by the same authors reveals that there were no significant differences in reported ERBs among students who had lived in a

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5 The "exposure effect" (Bornstein, 1989) suggests that beyond early childhood development (in which human cognitive functioning predominantly favors novel stimuli), exposure to a stimuli is associated with positive affect toward that stimuli. Thus, it is suggested that increasing familiarity through daily interactions with a green building will support positive feelings about green buildings and sustainability, which could potentially support ERBs. Empirical research has yielded mixed evidence in support of the claims that familiarity with a building's green features should positively influence occupant satisfaction and likelihood to adopt ERBs (Day & Gunderson, 2015; McCunn & Gifford, 2012; Steinberg et al., 2009) . This issue merits additional research.

green residence hall versus a conventional residence hall three years before (Watson, Hegtvedt, Johnson, Parris, & Subramanyam, 2017).

Another substantial gap in the current literature on occupant ERBs in residence halls is the issue of long-term durability of behavior. Formal behavior change interventions are inherently time-limited, often employing a pre-post measure to assess the effectiveness of the intervention tool. Additionally, the tenure of the average undergraduate student in on-campus housing is limited, which poses a challenge for conducting a longitudinal study on ERBs over time. While interventional strategies may be effective during the treatment period, it is unknown whether students would eventually habituate to the intervention (e.g., fail to attend to feedback on an energy dashboard or cease to be motivated by an incentive or competition) and if their change in behavior would return to pre-intervention levels. To address this issue, research is needed to identify the existing psychological dimensions that support ERBs in undergraduate students and design their environments (in this case, on-campus residence halls) to support these inclinations.

Methods

The aim of the present study is to illuminate the personal and contextual factors that influence undergraduate environmentally responsible behaviors in green[6] and conventional residence halls (see Figure III.1). The current study addresses three research questions:

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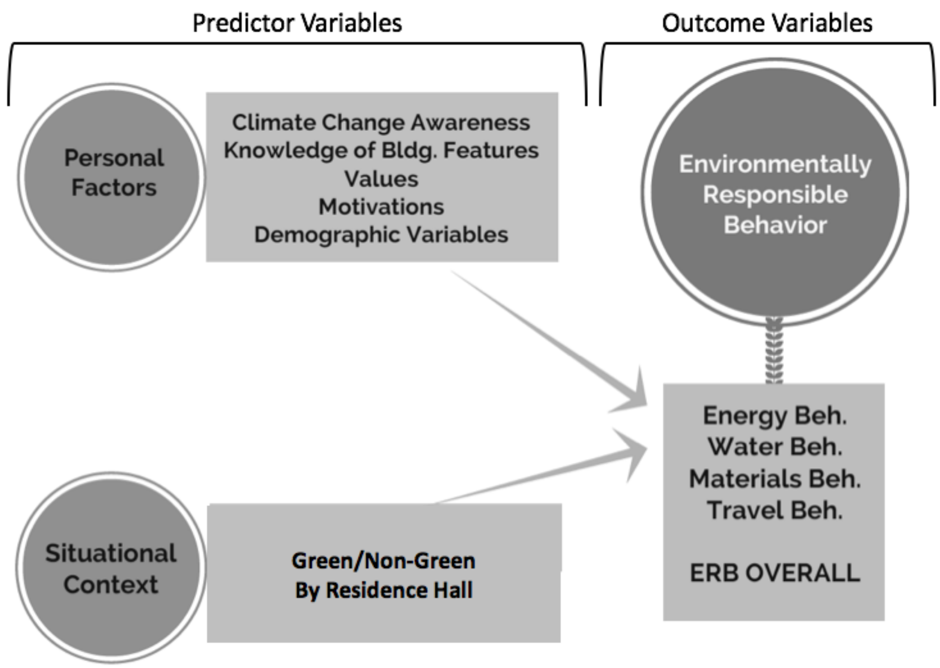
6 "Green" in this study refers to a building that meets the standards for LEED® certification at the Gold level or higher. To achieve LEED® Gold certification, building projects must obtain a minimum of 60 out of 100 points, which signal construction and operational processes as well as features that address environmental responsibility in the following categories: sustainable sites; location and transportation; energy and atmosphere; water efficiency,

Research Question 1 (RQ1): What individual-sphere variables predict undergraduate ERBs in the categories of Energy, Water, Materials, and Travel within campus residence halls?

Research Question 2 (RQ2): Does living in a green versus a conventional residence hall increase the level of ERBs reported by students?

Research Question 3 (RQ3): Do student ERBs increase over time and is there a greater effect in green versus conventional residence halls?



III.1. Conceptual Diagram of Research Design, Chapter III
Chapter III evaluates the person and situational factors that influence occupants' environmentally responsible behaviors in green and non-green residence halls.

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materials and resources; indoor environmental quality, innovation in design; and credits pertaining to regional priorities (U.S. Green Building Council, 2016).

Participants

The study involved an online longitudinal survey of the behaviors, knowledge, values, and motivations of undergraduate students living in green and conventional residence halls at two university campuses. Most students had the opportunity to select the residence hall in which they would reside, however it is unknown how many students were placed in their first-choice residence hall. The possibility that this self-selection affected their adoption of environmentally responsible behaviors will be discussed later. All students who were first-time residents of their halls were invited to participate in the study, which included an online survey at two times during the 2016-2017 academic year. In total, 388 students took the survey in the Fall 2016 semester (T1) and 187 students took the survey in the Spring 2017 semester (T2), for a response rate of 23.6% and 11.4% respectively. Fifty-four students took the survey at both T1 and T2.

Students reported an average age of 19 years and ranged between 18-26 years old. While all students were first-time residents in their particular dormitory, the sample was diverse with respect to their year in college, ranging from one to five. However, the majority of students reported being in their first year (72.2%), followed by second year students (21.1%). The participants who reported their gender consisted of 62.6% female, 35.4% male, and 1.9% identified as non-binary or gender fluid. Students reported a variety of academic majors, with the preponderance of students studying in a STEM field (74.1%); 24.5% majored in the Social Sciences or Humanities, and 4.1% reported majors specifically in a field related to the environment. The majority of students were from the United States (94.4%) with 5.6% representing international students.

Residence Halls

The study included six undergraduate residence halls from two Midwestern universities (University A and University B). At each university, two of the residence halls were LEED® Gold certified[7] (A.1, A.2, B.1, B.2) and one residence hall was a conventional building (A.3, B.3). While there are numerous ways to define sustainability with respect to the building industry, the researcher chose to operationalize green building by having achieved or met LEED® certification standards. Compared to Energy Star, another common sustainable rating system, LEED® addresses impact areas that have the potential to be visible to occupants and to interact with behavior. Using LEED® certified buildings also afforded a means to "quantify" sustainability within the buildings as scorecards accounting for how each building attained the credits to meet LEED® certification are publicly available through the U.S. Green Building Council (USGBC) website. A blank LEED® scorecard (version 2009) for New Construction projects is provided in Appendix A.

Identification of the case study sites began with a search of the U.S. Green Build Council database of completed LEED® version 2009 certified projects in the U.S. The search was restricted to undergraduate residence halls within the same geographic area to maintain a similar physical climate. Both universities are large, public institutions with University A responsible for approximately 33,500 undergraduate students in Fall 2016 and University B approximating 29,500. Both universities demonstrate a similar culture of sustainability characterized by: 1) a demonstrated growth of sustainable infrastructure, 2) curricular offerings focusing on sustainability, and 3) university offices or centers of sustainability that frame the campus as "a

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7 Residence Hall B.1 meets LEED® Gold standards but did not officially certify.

living model of sustainability" (University B) or a "living laboratory for sustainability" (University A).

The residence halls vary with respect to age, with the green residence halls built within the last six years and the two conventional halls built in the 1950s with only minor renovations in finishes since then. However, despite the age of the buildings, the halls share many functional similarities. All provide shared rooms[8] with communal spaces for lounging and socializing; studying; laundry; and computer facilities. The residence hall bath and shower room has evolved considerably over time – various iterations of the dormitory bathroom are implemented across the six residence halls. Residence halls have traditionally offered students communal bathrooms with sinks, toilets, and showers to be shared among students by floor or wing of the building. Halls A.1, A.3, B.1, and B.2 provide communal bath and shower rooms with three to four toilets and showers per every four to five rooms (or up to ten students). In building A.2, four private bathrooms consisting of a single toilet, sink, and shower stall, are clustered together and accessible to six shared rooms in a configuration called a *pod*. Each pod shares its own mini-hallway in a small branch off the main corridor that extends the length of the building. Private bath and shower rooms are only available in building A.1 within a select wing of rooms for students with severe physical disabilities, and in all rooms of B.3, which was converted from its original purpose as a university conference center and hotel.

Survey Creation

The purpose of the survey was to assess the antecedents of students' environmental behaviors in green and non-green residence halls over time. ERB was divided into four

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8 Resident Advisors typically occupy single rooms in each hall. Additionally, in building A.1 students with severe physical disabilities live in ADA accessible private rooms with private bathrooms.

categories of behavior, derived from the dominant categories in the LEED® certification system with the most directly identifiable impacts on occupant behavior: Energy, Water, Materials, and Travel. The survey was subdivided into sections based on each behavioral category and included a bank of questions about students' typical behavior relative to the category, their perceived and actual knowledge of green building features, perceived knowledge of relevant ERBs, motivations, values, and demographics. Demographic questions at the end of the survey included the student's age, gender, nationality (domestic or international student), major, and year in school.

Environmentally responsible behaviors were assessed via a 7-point Likert scale (e.g., 1 = Never, 4 = Sometimes, 7 = Always) with an eighth point for Not Applicable. For each behavior category, students were asked to consider how often they typically perform a series of behaviors. Examples of energy conservation behaviors include turning off lights when leaving one's bedroom, turning off lights when leaving a common room, and using the power savings settings on one's computer. Each behavior category contained an average of nine items, which were partially adapted from a longitudinal survey in use at the University of Michigan (Marans & Callewaert, 2015) that tracks student, faculty, and staff environmental behaviors, attitudes, and values.

Students' knowledge was assessed through a variety of Likert scales and open-response questions. Declarative knowledge about climate change was assessed through a 5-point Likert scale (1 = Completely Disagree, to 5 = Completely Agree) that asked students to consider how much they agreed or disagreed with statements regarding the belief that the earth's climate is changing, the dominant causes of the changing climate, and an assessment of their ability to explain the topic of climate change to a friend. *Climate change awareness* was calculated via the mean of the items within this bank. Within each behavior category (Energy, Water, Materials/Waste, and Travel), students were asked to assess their own knowledge of the sustainable features of their residence hall and how much they know about behaviors they could perform to conserve resources relative to the category. Students used a 5-point Likert scale (1= "Nothing" to 5 = "I know more than most of my peers") to indicate their *Perceived knowledge of sustainable building features* and *Perceived knowledge of conservation behaviors*. Students were also asked to generate a list of up to three features of their residence halls that helped to conserve energy (or water, materials, travel behavior) or they could indicate "I don't know."

The study included two banks of items that measured values and motivations. While it is often assumed that a person committed to environmental causes must be motivated by a deep commitment to protecting the natural world, a wide variety of values and motivations have been shown to support and emerge from participating in ERBs. This study sought to capture the range of values and motivations that influence undergraduate students' ERBs in residence halls (De Young, 1996; De Young et al., 1993; Grese et al., 2000; Jagers & Matti, 2010; Ryan et al., 2001; Stern, 2000). A bank of 15 items was created to measure students' values. These items were drawn from the literature, namely Stern's (2000) Value-Belief-Norm theory of environmentalism, which suggests there are three dominant categories of values: altruistic, biospheric, and egoistic. Altruistic, or social, values relate to care for the well-being of others. As the environment is a public good, behaviors that protect and conserve the environment are viewed as an extension of how one cares for other people. In a related fashion, biospheric values refer to care for non-human nature. Lastly, egoistic, or self-enhancement, values have been empirically associated with negative ERBs (Stern, 2000); however, other research suggests framing environmental messages to appeal to alternate values, like self-protection, can be effective in cultivating ERBs (Pelletier & Sharp, 2008). Students were asked to consider how important or unimportant 15 statements were as guiding principles in their lives. Participants indicated the degree to which they endorsed each value statement by sliding an icon along a numeral scale ranging from 0 to 100, where 100 indicated the value was extremely important.

Motivations were assessed via a similarly structured bank of items asking students to indicate how motivating a series of items would be in encouraging them to participate in an activity. Students responded to the 28 items by sliding an icon along a scale ranging from 0 to 100, where 100 indicated that the item would be extremely motivating. The list of items was derived from the literature on motivations of environmentally responsible behavior and participation in environmental stewardship programs (Bramston et al., 2010; De Young, 2000; Grese et al., 2000) In total, the list included items representing eight motivations: social belonging, personal well-being, care for the environment, participation in something meaningful, exploration or competence-building, frugality, spiritual growth, and having access to consumer goods and technology.

The survey and all scripted communications with study participants were approved by the University of Michigan Institutional Review Board (eResearch ID # HUM00117575). Participants were informed that they could withdraw from the study at any point in time. (See Appendix B for the full survey).

Data Collection

The survey was created in Qualtrics, an online survey methodology tool, and distributed via a unique link per each residence hall to a single contact person at each university. University contacts distributed the survey link and invitation email (See Appendix C) to all first-time residents of the six target residence halls at two points in time during the 2016-2017 academic year. The fall survey was distributed three weeks following the first day of classes at each University. For University A, the invitation email was first sent on September 8, 2016 and for University B, the invitation email was sent on September 19, 2016. The spring survey was distributed on February 20, 2017 to both universities[9]. The surveys remained open for three weeks, during which students received two follow-up emails from the researcher (See Appendix C), which were distributed by the campus contact person. The researcher incentivized participation by notifying students that they could provide their email address for a drawing to win one of four $25 gift cards per residence hall, in both the fall and spring semesters. Students' email addresses collected for the drawing were immediately removed from the data and documented in a separate spreadsheet. Gift card recipients were chosen via a random-number generator and students were contacted via their email address to provide a mailing address to which the gift card could be sent. No other identifying information was collected during this study. Rather, in order to track individual student behavior over time, students were asked to create a unique passcode that they would use in both the fall and spring semester survey. Use of the passcode to track behavior change will be discussed further in the Data Analysis section below.

Data Analysis

Constructs and Measures: The data was analyzed in IBM SPSS Statistics version 24. Responses were eliminated for students who indicated they had lived in the residence hall prior

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9 Ideally the students would have been surveyed later in the spring semester; however, both universities had previously planned to participate in dorm-based and campus-wide sustainability challenges that would have resulted in biased responses. Thus, the spring survey dates reflected the latest possible dates before advertising for these environmental campaigns were to begin.

to the 2016-2017 academic year. Additionally, participant responses were removed if they did not progress far enough into the survey to complete the Climate Change Awareness items, which were the first set of psychological dimensions included in the survey.

Each response was assigned a participant ID number; students who had provided a matching passcode on the T1 (fall) and T2 (spring) survey were matched and given the same participant ID. Thus, participants 1-54 have data recorded for both the fall and the spring. Composite behavior scores in the four categories (Energy, Water, Materials/Waste, and Travel), plus one category for ERB Overall, were calculated via the mean score of the items in that category. Where applicable, participant responses were reverse coded to account for items stated in the negative.

A principal axis factor analysis with varimax rotation was conducted on the bank of 15 Values items for participants who took the survey in Fall 2016. The initial analysis produced three factors with eigenvalues above Kaiser's criterion of 1 (Field, 2015; H. F. Kaiser, 1960) and together these explained 52.67% of the variance. Inflexion points in the scree plot suggested retaining either two or four factors. However, consistent with Kaiser's criterion, three conceptually distinct factors were identified with items loading above .45. Only one item (Q34_10: Working for peace in the world) loaded on two factors and therefore was eliminated when new categories were created following the factor analysis. Table III-1 shows the factor loadings after rotation and the Cronbach's alpha for each factor. The items clustered under each factor represent the following value orientations: Biospheric (factor 1), Social (factor 2), and Egoistic (factor 3). This structure is consistent with the literature that informed the survey creation. Biospheric, Social, and Egoistic Values scores were created by calculating the mean of the items included within each factor.

Table III-1. Student Values: Summary of Principle Axis Factor Analysis Results

	Rotated Factor Loadings		
	Biospheric Values	**Social Values**	**Egoistic Values**
Protecting natural resources (Q34_15)	**0.88**	0.15	0.12
Preventing pollution (Q34_9)	**0.82**	0.24	
Fitting in with nature (Q34_14)	**0.73**	0.23	
Preserving nature (Q34_4)	**0.71**	0.25	
Being in harmony with other living species (Q34_2)	**0.61**	0.30	
Working for the welfare of others (Q34_3)	0.27	**0.68**	
Correcting injustices locally or abroad (Q34_13)	0.36	**0.65**	0.13
Caring for the weak (Q34_6)	0.19	**0.64**	
Working for peace in the world (Q34_10)	0.45	0.59	
Having an impact on people and events (Q34_1)	0.16	**0.54**	0.16
Making sure everyone has equal opportunities (Q34_8)	0.41	**0.53**	
Leading a group of people (Q34_5)		**0.49**	0.39
Making a high salary in my field (Q34_12)			**0.75**
Having the material possessions I choose (Q34_7)			**0.64**
Having influence amongst my social group (Q34_11)	0.11	0.42	**0.53**
Eigenvalues	3.50	2.92	1.48
% of variance	23.33%	19.45%	9.89%
Cronbach's α	0.89	0.81	0.68

Note: Factor loadings above 0.45 appear in bold. Items that loaded above 0.45 on more than one factor were eliminated.

The 28 Motivation items were also assessed via a principal axis factor analysis with varimax rotation. An initial analysis produced five factors with eigenvalues above Kaiser's criterion and together these explained 60.13% of the variance. However, three of the items failed to load above .45 on any of the factors, including item Q35_19 (Influence how society solves problems), which would have been the only item in the fifth category. Inflexion points in the scree plot suggested retaining either 3 or 5 factors. A four-factor solution was attempted, which accounted for 57.845% of the variance with multiple items loading on more than one factor that would need to be eliminated. Given the large size of the sample, a six-factor solution was attempted, which ultimately produced five coherent factors with eigenvalues above 1. Together, these factors accounted for 60.267% of the variance. Therefore, the final solution adopted this five-factor structure. Three items (Q35_19: Influence how society solves problems; Q35_22: See familiar faces; Q35_21: Chance to have a leadership role) failed to load above .45 on any factor and were therefore eliminated when the new categories were created. Table III-2 shows the factor loadings after rotation and the Cronbach's alpha for each factor. The items clustered under each factor represent the following categories of Motivations: Environmental Concern (factor 1), Self-interest (factor 2), Participate in Society (factor 3), Technology (factor 4), and Spirituality (factor 5).

Table III-2. Student Motivations: Summary of Principle Axis Factor Analysis Results

	Rotated Factor Loadings				
	Environmental Concern	**Self-Interest**	**Participate in Society**	**Techno-logy**	**Spiritu-ality**
Help restore natural areas (Q35_23)	**0.88**	0.15	0.11	0.11	
Care for the land (Q35_20)	**0.84**	0.21	0.15		0.11
Protect natural places from disappearing (Q35_11)	**0.83**	0.23	0.16		
Make the environment better for others (Q35_28)	**0.81**	0.26	0.19		
Consume a minimum amount of resources (Q35_26)	**0.78**	0.12	0.19		0.28
Find ways to avoid waste (Q35_8)	**0.69**	0.17	0.29	0.19	0.21
Learn about my surroundings (Q35_10)	**0.62**	0.26	0.25	0.12	0.40
Use something borrowed or second-hand rather	**0.57**	0.13	0.16		0.29

than buying new (Q35_27)					
Do something that helps bring order to the world (Q35_24)	**0.56**	0.40	0.24	0.10	0.12
Chance to be outdoors (Q35_5)	**0.45**	0.15	0.36	0.10	0.18
Improve my outlook on life (Q35_16)	0.28	**0.72**	0.29		0.16
Discover new things I'm not yet competent at doing (Q35_18)	0.31	**0.60**	0.31	0.28	0.16
Do something that nobody else is doing (Q35_15)	0.13	**0.57**	0.20	0.29	0.19
Make life more simple (Q35_17)	0.28	**0.57**		0.22	0.21
Have a story to tell people (Q35_12)		**0.48**	0.19	0.14	0.43
Opportunity to try something new (Q35_25)	0.35	**0.45**	0.44		0.15
Influence how society solves problems (Q35_19)	0.36	0.41	0.31	0.22	0.16
See familiar faces (Q35_22)	0.16	0.39	0.29	0.19	
Chance to have a leadership role (Q35_21)	0.24	0.38	0.34	0.13	0.16
Spend time for a good purpose (Q35_2)	0.30	0.19	**0.79**		0.14
Meet new people (Q35_1)		0.17	**0.71**		0.13
Learn new skills (Q35_3)	0.19	0.19	**0.71**	0.23	0.15
Feel good about myself (Q35_4)	0.19	0.43	**0.55**		
Help others do something important (Q35_7)	0.32	0.42	**0.48**		0.18
Try out a new product or gadget (Q35_6)	0.14	0.15	0.21	**0.91**	
Use the latest technology (Q35_14)		0.33		**0.74**	
Chance to reflect (Q35_13)	0.33	0.37	0.25		**0.65**
Contribute to my spirituality (Q35_9)	0.21	0.21	0.18		**0.45**
Eigenvalues	6.19	3.69	3.54	1.88	1.57
% of variance	22.11%	13.17%	12.65%	6.73%	5.61%

Cronbach's α	0.94	0.86	0.86	0.85	0.67

Note: Factor loadings above 0.45 appear in bold. Items that loaded above 0.45 on more than one factor were eliminated.

RQ1 and RQ2: To assess the personal and contextual factors that predict undergraduate ERBs in on-campus residence halls, a linear mixed effects regression (LMER) procedure was used. As one of the major assumptions of linear models is the independence of the samples, Participant ID was entered as a nested random effect[10], along with Residence Hall, and University. Five LMER models were created: one for each outcome variable, corresponding to the four behavior categories (Energy, Water, Materials/Waste, and Travel), plus one additional model for ERB Overall. The models initially included fixed effects for the demographic variables: Gender, Major, Year in School, and Nationality. Age was not included in the model as it co-varied highly with Year in School, which was more relevant to predicting students' ERBs in on-campus residence halls. The model also included fixed effects of the categorical variables Survey Time (Fall or Spring) and Green Building (Green or Conventional), as well as the continuous variables: Biospheric Values, Social Values, Egoistic Values, Environmental Concern Motive, Self-interest Motive, Participate in Society Motive, Technology Motive, Spirituality Motive, Climate Change Awareness, Perceived Knowledge of Conservation Building

10 The nested random effects account for any additional variation due to these variables that is not captured in the fixed effects of the model. The models initially included the nested random effects for Student ID, Residence Hall, and University. Following each of the initial analyses, Residence Hall and University were removed as they were statistically close to zero, indicating that no additional variance was being captured by the random effects for these two variables.

Features[11], Perceived Knowledge of Conservation Behaviors, Identification of Conservation Building Features, and Identification of Conservation Behaviors.

Initial models were adjusted through a process of variable selection, which removed variables one at a time by first identifying a single variable with the highest non-significant p-value, removing it from the model, and comparing the Bayesian Information Criterion (BIC) for model fit. The BIC score effectively gauges the efficiency of the model in predicting the data by penalizing excess complexity due to a larger number of variables. Lower BIC scores indicate more efficient, better fit models (Schwarz, 1978). Variable selection was conducted using this method of comparing BIC scores until reaching one of two conditions: 1) the BIC score increased after removing a variable, or 2) if eliminating the variable with the next highest non-significant p-value would necessitate removing a variable of relevance to the research questions. This process resulted in removing Nationality from all of the models, which was reasonable since the sample population was largely homogenous (94.4% domestic students[12]), resulting in any differences between domestic and international students adding very little variation to the model. The variable reduction procedure also resulted in removing Year in School from the models predicting Energy Conservation Behavior, Water Conservation Behavior, and ERB Overall.

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11 The Perceived Knowledge and Identification variables are specific to each behavior category. For example, when completing the energy section of the survey, students were asked to indicate how much they know about energy conservation building features. When completing the water section of the survey, students were asked to indicate how much they know about water conservation building features, and so on.

12 The percentage of international students in the study sample was lower than would be proportionate considering the size of the on-campus undergraduate population. This is perhaps due to the fact that none of the residence halls included in the study would be open to students during semester breaks, which would likely be a deterrent to international students.

RQ3: To assess the change in ERBs by students in green versus conventional residence halls over time, the same linear mixed effects regression procedure was followed. In the above described models, the Green Building variable was combined with Survey Time as an interaction effect. Following non-significant results in each of the models, the interaction effect was removed. In examining the raw data, the researcher hypothesized there were interaction effects at the level of the individual residence halls over time (i.e., the magnitude of change in behavior from T1 to T2 seemed to differ by individual residence hall rather than by green/conventional halls). The above LMER models were tested again with a new categorical variable for individual Residence Hall and included an interaction effect for Residence Hall and Survey Time.

Results

The data explored three research questions (RQs): to identify the individual factors responsible for undergraduate ERBs in on-campus housing (RQ1); to explore the physical context of green buildings in supporting ERBs (RQ2); and to explore the interaction effect of time and greenness of residence hall on students' ERBs (RQ3).

RQ1 and RQ2: Personal and Contextual Variables Related to ERBs in Residence Halls

Energy Conservation Behavior. With respect to RQ1, results from the linear mixed effects regression analyses for Energy behavior are shown in Table III-3. The results show four variables are significantly associated with undergraduate Energy conservation behavior in residence halls. The variable that predicts the most change in Energy behavior is Gender, with participants who identify as Male reporting 0.197 lower Energy conservation scores than females ($\beta = -0.197$, $p < .05$). Also associated with decreased Energy conservation behavior is an Egoistic Value orientation where for every one-point increase along the 0 to 100 values scale, Energy conservation behavior declines by 0.009 ($\beta = -0.009$, $p < .01$). Both the Technology Motive ($\beta = 0.005$, $p < .05$) and students' Perceived Knowledge of Energy Conservation Building Features ($\beta = 0.168$, $p < .01$) predict higher Energy conservation scores. With regard to RQ2, the results indicate that living in a green residence hall was not associated with greater Energy conservation behavior scores than living in a conventional residence hall.

Water Conservation Behavior. Four factors had statistically significant impacts on undergraduate students' Water conservation behavior (see Table III-3). As with Energy behavior, Egoistic values predicted lower Water conservation scores ($\beta = -0.006$, $p < .05$). Also associated with decreased responsible water usage is the motivation to Participate in Society where every one-point increase on the 0 to 100 motivation scale predicts a 0.009 decline in Water conservation behavior ($\beta = -0.009$, $p < .05$). Predicting positive growth in Water conservation behavior are students who indicate being motivated by Environmental Concern ($\beta = 0.008$, $p < .05$). Addressing RQ2, the results indicate that living in a green residence hall was not significantly associated with greater Water conservation behavior scores than living in conventional residence halls.

Materials/Waste Conservation Behavior. Results from the linear mixed effects regression model predicting Materials/Waste conservation behavior are displayed in Table III-3. Both Gender and the Egoistic Value orientation predict significantly lower Materials/Waste conservation behavior. Participants who identify as Male report 0.314 lower Materials/Waste conservation scores than females ($\beta = -0.314$, $p < .001$). Egoistic Values are associated with lower Materials/Waste conservation behavior where for every one-point increase along the 0 to 100 values scale, Materials/Waste conservation behavior declines by 0.008 ($\beta = -0.008$, $p < .001$). Biospheric Values and the Environmental Concern Motive are significantly related to an increase in Materials/Waste conservation behavior. Increasing one point in Biospheric Values results in a 0.006 increase in Materials/Waste conservation ($\beta = 0.006$, $p < .05$) and the same increase in Environmental Concern motive results in 0.007 improved Materials/Waste conservation score ($\beta = 0.007$, $p < .05$). Being motivated by Technology also predicts a significant increase in Materials/Waste conservation ($\beta = 0.006$, $p < .01$). Lastly, students in their third year of school report significantly higher Materials/Waste conservation behavior than students in their fifth year ($\beta = 0.841$, $p < .05$). The results reveal that there was no significant difference between green and conventional residence halls with respect to students' Materials/Waste conservation behaviors (RQ2).

Travel Behavior. With respect to environmentally responsible Travel behavior, students' Perceived Knowledge of Travel Alternatives predicts improved Travel behavior scores ($\beta = 0.234$, $p < .001$). A very small effect of Spirituality was also significantly associated with improved Travel behavior ($\beta = 0.004$, $p < .05$). The results indicate that living in a Green residence hall was significantly associated with poorer Travel behavior ($\beta = -0.261$, $p < .01$).

Table III-3. Personal and Contextual Antecedents of ERBs in Undergraduate Residence Halls –

Linear Mixed Effects Regression Models

		ENERGY BEHAVIOR			WATER BEHAVIOR			MATERIAL BEHAVIOR			TRAVEL BEHAVIOR			ERB OVERALL		
	Variable	Estimate	t-statistic	p-value	Estimate	t-statistic	p-value	Estimate	t-statistic	p-value	Estimate	t-statistic	p-value	Estimate	t-statistic	p-value
	Intercept	3.345	7.628	0.000	4.066	9.776	0.000	3.444	6.510	0.000	3.482	6.946	0.000	3.572	14.587	0.000
Gender	Male	- 0.197	- 2.089	0.038*	- 0.181	- 1.953	0.052	- 0.314	- 3.58	0.000***	- 0.062	- 0.747	0.456	- 0.170	- 3.102	0.002**
	Non-binary	0.150	0.414	0.684	0.091	0.265	0.791	0.063	0.195	0.846	0.200	0.648	0.518	0.131	0.634	0.527
	Female	0[b]	.	.	0[b]	.	.	0[a]	.	.	0[a]	.	.	0[a]	.	.
Major	Social Sciences and Humanities Majors	0.172	0.752	0.445	- 0.178	- 0.787	0.432	- 0.121	- 0.594	0.553	0.062	0.300	0.765	- 0.008	- 0.065	0.949
	STEM/Business Majors	0.028	0.126	0.890	- 0.153	- 0.697	0.486	- 0.059	- 0.3	0.765	0.076	0.377	0.706	- 0.020	- 0.162	0.872
	Environmental Fields	0[a]	.	.	0[a]	.	.	0[a]	.	.	0[a]	.	.	0[a]	.	.
Year In School	1st Year	–	–	–	–	–	–	0.722	1.957	0.052	- 0.590	- 1.744	0.083	–	–	–
	2nd Year	–	–	–	–	–	–	0.619	1.666	0.097	- 0.491	- 1.441	0.151	–	–	–
	3rd Year	–	–	–	–	–	–	0.841	2.067	0.040*	- 0.220	- 0.578	0.564	–	–	–
	4th Year	–	–	–	–	–	–	0.223	0.504	0.615	- 0.230	- 0.549	0.583	–	–	–
	5th+ Year	–	–	–	–	–	–	0[a]	.	.	0[a]	.	.	–	–	–
Survey Time	Spring	0.098	1.259	0.401	0.140	2.054	0.042*	0.150	2.45	0.016**	0.004	0.062	0.951	0.090	2.134	0.034*
	Fall	0[a]	.	.	0[a]	.	.	0[a]	.	.	0[a]	.	.	0[a]	.	.
Green Bldg.	Green	- 0.126	- 0.746	0.566	0.094	0.985	0.326	- 0.072	- 0.807	0.420	- 0.261	- 3.040	0.003**	- 0.108	- 1.873	0.062
	Conventional	0[a]	.	.	0[a]	.	.	0[a]	.	.	0[a]	.	.	0[a]	.	.
	Biospheric Values	0.001	0.356	0.722	0.004	1.390	0.166	0.006	2.054	0.041*	0.003	1.018	0.310	0.004	2.095	0.037*
	Social Values	- 0.001	- 0.297	0.776	- 0.003	- 0.911	0.363	0.000	0.096	0.924	0.000	0.028	0.978	- 0.001	- 0.710	0.478
	Egoistic Values	- 0.009	- 3.491	0.001**	- 0.006	- 2.285	0.023*	- 0.008	- 3.589	0.000***	- 0.003	- 1.205	0.229	- 0.006	- 4.399	0.000***
	Environmental Concern Motive	0.005	1.412	0.167	0.008	2.351	0.019*	0.007	1.997	0.047*	0.000	0.048	0.962	0.005	2.608	0.010*
	Self-interest Motive	0.001	0.300	0.745	- 0.002	- 0.599	0.550	- 0.002	- 0.522	0.602	- 0.004	- 1.312	0.191	- 0.002	- 0.878	0.380
	Participate in Society Motive	0.000	- 0.056	0.958	- 0.009	- 2.426	0.016*	- 0.005	- 1.331	0.184	0.004	1.219	0.224	- 0.002	- 0.815	0.416
	Technology Motive	0.005	2.472	0.014*	- 0.002	- 1.074	0.284	0.006	3.131	0.002**	0.002	1.437	0.152	0.002	2.016	0.045*
	Spirituality Motive	- 0.001	- 0.248	0.808	0.001	0.502	0.616	0.003	1.329	0.185	0.004	2.038	0.043*	0.001	1.094	0.275
	Climate Change Awareness	0.069	0.976	0.333	0.113	1.645	0.101	0.044	0.681	0.497	- 0.001	- 0.022	0.983	0.053	1.300	0.195
	Perceived Knowledge of Conservation Building Features[bc]	0.168	3.225	0.001**	0.072	1.695	0.091	0.045	1.218	0.224	0.234	5.111	0.000***	0.090	2.300	0.022*
	Perceived Knowledge Conservation Behaviors[bc]	0.007	0.138	0.902	0.050	0.944	0.346	0.031	0.696	0.487	–	–	–	0.082	1.597	0.111
	Identification of Conservation Building Features[b]	- 0.026	- 0.559	0.566	0.004	0.084	0.933	0.040	0.935	0.351	- 0.083	- 1.618	0.107	- 0.005	- 0.119	0.905
	Identification of Conservation Behaviors[b]	0.030	0.409	0.681	0.016	0.332	0.741	0.027	0.339	0.735	0.062	1.097	0.274	0.012	0.201	0.841

*$p < .05$, ** $p < .01$, *** $p < .001$

[a] Reference level

– Variable not included in model

[b] Relevant to behavior category (e.g., Knowledge of *Energy* Conservation Building Features or *Energy* Conservation Behaviors)

[c] For Travel Behavior, Perceived Knowledge is combined into one variable: Perceived Knowledge of Travel Alternatives

ERB Overall. When combined together into a single measure of ERB Overall, students' environmentally responsible behaviors are significantly improved by Biospheric Values (β = 0.004, $p < .05$) and the motive of Environmental Concern (β = 0.005, $p < .05$). Students' reported ERB Overall scores significantly increase with the Technology motivation (β = 0.002, $p < .05$) and increased Perceived Knowledge of Conservation Building Features (β = 0.090, $p < .05$). Consistent with the individual behavior categories, Egoistic values are significantly associated with decreased ERB Overall (β = -0.006, $p < .001$). Males differed significantly from females with respect to ERB Overall, resulting in 0.170 lower ERB scores overall for males (β = -0.170, $p < .01$). Regarding RQ2, there was no statistically significant effect of the Building Greenness on students' ERBs.

RQ3: Change in ERBs Over Time Among Green and Conventional Residence Halls

Change in Energy Conservation Behavior. If considered collectively there was no statistically significant change in Energy conservation behaviors over time among the residence halls. However, when considered individually, the results suggest an overall positive trend in students' Energy conservation behaviors over time, except for in hall A.2, which declined (see Figure III.2). Further, the change in behavior from T1 to T2 in building A.2 was significantly different than the change that occurred in B.2 (β = -0.849, $p < .01$)[13]. See Table III-4 for the full results.

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13 For RQ3, the results should be interpreted as the difference in the slope (that is, the difference in the differences) of behavior scores between T1 and T2. The slope of the line formed between the mean behavior score at T1 and the mean behavior score at T2 represents the change over time in behavior within a single residence hall. The β indicated in the results therefore indicates the difference between the slopes of the lines between the T1 and T2 mean behavior scores of two residence halls.

Change in Water Conservation Behavior. On average, Water conservation scores improved over time across all residence halls, as the responses from the Spring survey resulted in a statistically significant 0.140-point increase over the Fall ($\beta = 0.140$, $p < .05$) in the LMER containing Green Building as a variable (see Table III-3 previously). However, when individual Residence Hall is included as a variable rather than Green Building, the results reveal that five out of the six residence halls improved their Water conservation behavior, and one residence hall (A.2) declined (see Figure III.3). Further, the change from T1 to T2 in this one residence hall was significantly different than the change that occurred over time in four of the other residence halls (see Table III-5). The decline in Water conservation behavior that occurred from T1 to T2 in A.2 was significantly different than the increase over time in A.1 ($\beta = -0.603$, $p < .05$); A.3 ($\beta = -0.805$, $p < .05$); B.2 ($\beta = -0.652$, $p < .05$); and B.3 ($\beta = -0.828$, $p < .05$).

Change in Materials/Waste Conservation Behavior. Collectively, students across the six residence halls reported significantly higher (improved) Materials/Waste conservation behavior scores in the Spring than in the Fall ($\beta = 0.150$, $p < .05$). Upon individual examination, although two residence halls demonstrated slight declines in Materials/Waste conservation behavior (A.2 and A.3) (see Figure III.4), there were no significant differences among the residence halls in the amount they changed between T1 and T2, indicating that the rate of change from T1 to T2 was essentially the same except for in A.2 and A.3. See Table III-6.

Change in Travel Behavior. Considered together, students from the six residence halls did not report any significant changes in their Travel behavior between the fall and spring survey administration (see Figure III.5). Regression analyses including the residence halls individually also revealed no significant differences among the changes from T1 to T2 for each residence hall. See Table III-7.

Change in ERB Overall. On average, students across the six residence halls reported significantly higher ERB Overall at T2 than in T1 ($\beta = 0.090$, $p < .05$) (see Figure III.3). Students' ERB Overall scores improved over time in all of the residence halls, except A.2, which declined from T1 to T2 by -0.277 (see Figure III.6). Further, this change in ERB Overall for building A.2 is significantly different from the increase in ERB Overall from T1 to T2 in four of the other residence halls: A.1 ($\beta = -0.418$, $p < .05$); A.3 ($\beta = -0.425$, $p < .05$); B.2 ($\beta = -0.554$, $p < .01$); and B.3 ($\beta = -0.466$, $p < .05$). See Table III.8.

Table III-4. Differences in Change in Mean Energy Behavior by Residence Hall Over Time

Residence Hall	Change in Mean Energy Behavior Over Time	A.1	A.2	A.3	B.1	B.2	B.3
A.1	0.038						
A.2	-0.459	-0.497					
A.3	0.162	0.124	0.621				
B.1	0.102	0.064	0.561	-0.060			
B.2	0.390	0.351	0.849 **	0.227	0.288		
B.3	0.117	0.079	0.576	-0.045	0.015	-0.273	

*p<.05, **p<.01

The number in each cell represents the difference in the slopes of behavior over time between residence halls. The highlighted cell is equal to the residence hall indicated by the row name (at the left of the table) minus the residence hall indicated by the column name (at the top of the table). Thus, 0.849 is the difference between B.2 and A.2.

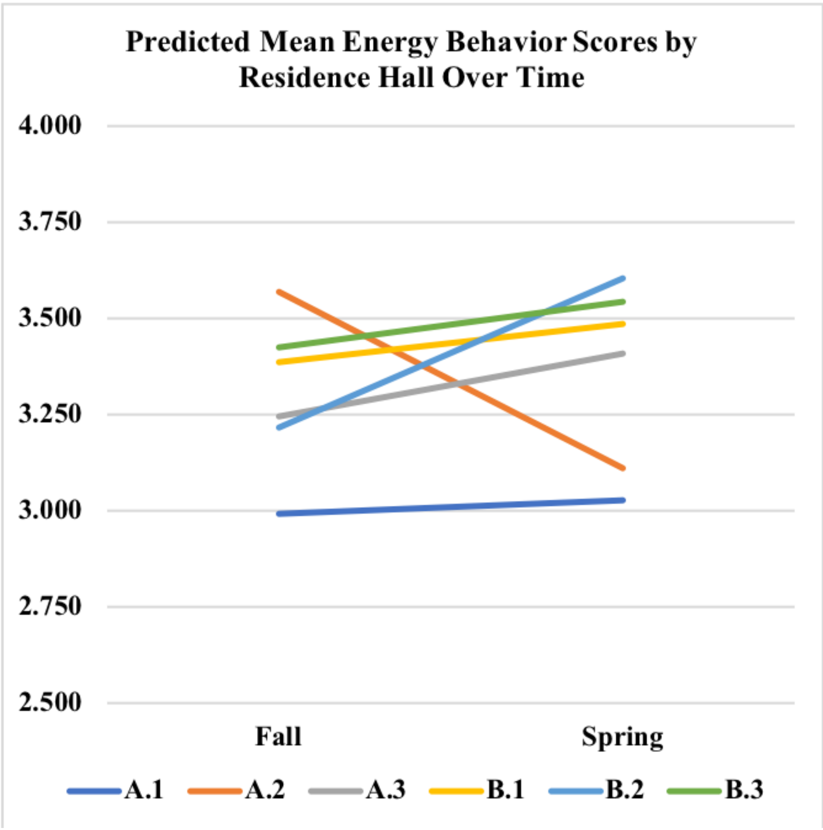

Figure III.2. Energy Behavior Scores by Residence Hall over Time
Results from the linear mixed-effects regression modeling the fixed predicted effects for Energy behavior by residence hall over time.

Table III-5. Differences in Change in Mean Water Behavior by Residence Hall Over Time

Residence Hall	Change in Mean Water Behavior Over Time	A.1		A.2		A.3	B.1	B.2	B.3
A.1	0.179								
A.2	-0.424	-0.603	*						
A.3	0.381	0.202		0.805	*				
B.1	0.109	-0.070		0.533		-0.272			
B.2	0.228	0.049		0.652	*	-0.153	0.119		
B.3	0.404	0.225		0.828	*	0.023	0.295	0.176	

*p<.05, **p<.01

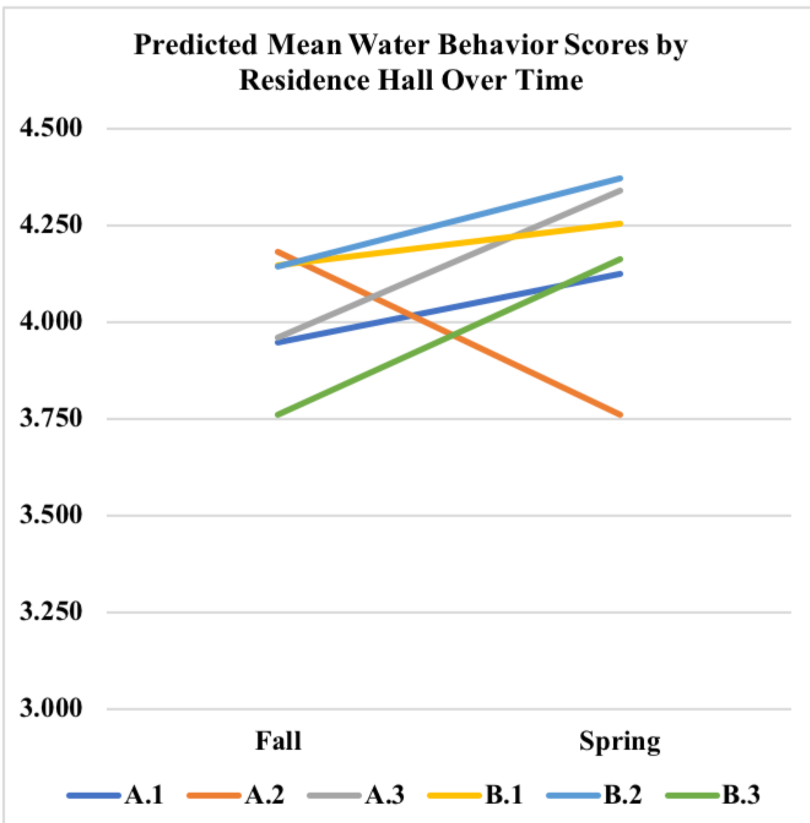

Figure III.3. Water Behavior Scores by Residence Hall over Time
Results from the linear mixed-effects regression modeling the fixed predicted effects for Water behavior by residence hall over time.

Table III-6. Differences in Change in Mean Materials Behavior by Residence Hall Over Time

Residence Hall	Change in Mean Materials Behavior Over Time	A.1	A.2	A.3	B.1	B.2	B.3
A.1	0.298						
A.2	-0.142	-0.440					
A.3	-0.053	-0.351	0.089				
B.1	0.059	-0.239	0.201	0.112			
B.2	0.350	0.052	0.492	0.403	0.291		
B.3	0.164	-0.134	0.306	0.218	0.105	-0.186	

*p<.05, **p<.01

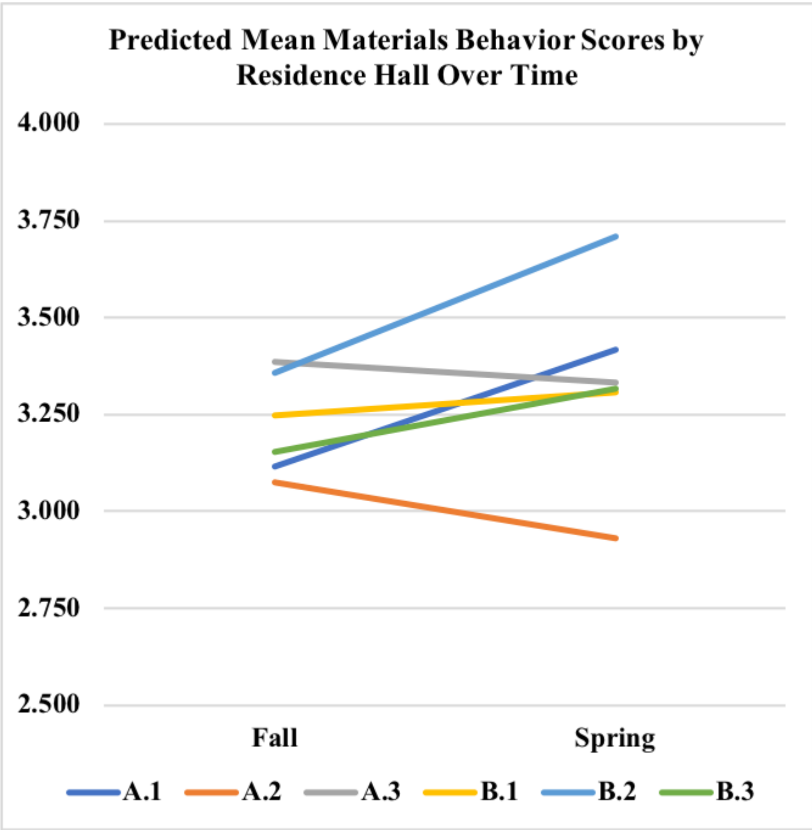

Figure III.4. Materials Behavior Scores by Residence Hall over Time
Results from the linear mixed-effects regression modeling the fixed predicted effects for Materials behavior by residence hall over time.

Table III-7. Differences in Change in Mean Travel Behavior by Residence Hall Over Time

Residence Hall	Change in Mean Travel Behavior Over Time	A.1	A.2	A.3	B.1	B.2	B.3
A.1	0.044						
A.2	-0.062	-0.106					
A.3	-0.106	-0.150	-0.044				
B.1	-0.083	-0.127	-0.021	0.023			
B.2	0.180	0.136	0.242	0.286	0.263		
B.3	0.087	0.043	0.149	0.193	0.170	-0.093	

*p<.05, **p<.01

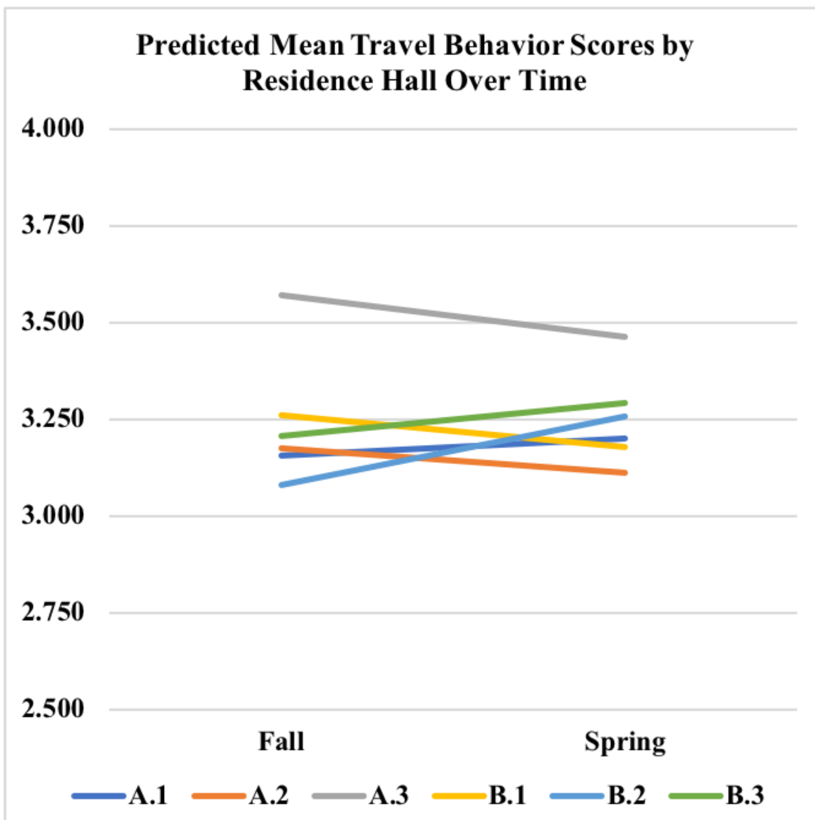

Figure III.5. Travel Behavior Scores by Residence Hall over Time
Results from the linear mixed-effects regression modeling the fixed predicted effects for Travel behavior by residence hall over time.

Table III-8. Differences in Change in Mean ERB Overall by Residence Hall Over Time

Residence Hall	Change in Mean ERB Overall Over Time	A.1	A.2	A.3	B.1	B.2	B.3
A.1	0.141						
A.2	-0.277	-0.418 *					
A.3	0.147	0.006	0.425 *				
B.1	0.051	-0.090	0.328	-0.097			
B.2	0.276	0.135	0.554 **	0.129	0.226		
B.3	0.188	0.047	0.466 *	0.041	0.138	-0.088	

*p<.05, **p<.01

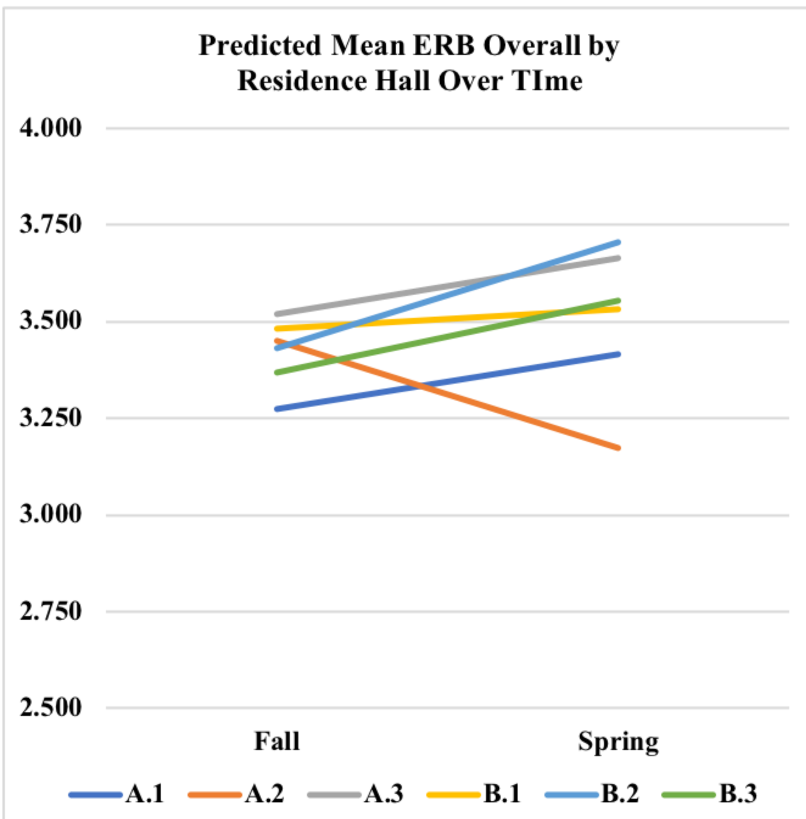

Figure III.6. ERB Overall Scores by Residence Hall over Time
Results from the linear mixed-effects regression modeling the fixed predicted effects for ERB Overall by residence hall over time.

Discussion

This study has three purposes: to identify the personal factors responsible for undergraduate ERBs in on-campus residence halls (RQ1); to explore the physical context of green buildings in supporting ERBs (RQ2); and to explore the interaction of time and greenness of residence hall on students' ERBs (RQ3). Several dominant trends emerge that have important implications for the design of residence halls to support undergraduate ERBs.

Personal Dimensions of ERB in Residence Halls

Values: Of the three values included in the model, Egoistic values are consistently associated with lower ERBs and this relationship is significant for Energy, Water, Materials/Waste, and ERB Overall. The Egoistic value cluster is composed of items emphasizing one's ability to earn a high salary, to acquire desired material possessions, and to have influence among one's social group. While Egoistic values have consistently been linked to poorer performance of ERBs, messages in the environment may be tailored to these values while successfully aligning to environmental stewardship goals. *Framing* refers to a means of conveying information in a particular way in order to be more easily understandable or accepted by a certain audience. For undergraduate students, framing environmental issues and behaviors to appeal to Egoistic values may involve highlighting the co-benefits of personal and planetary well-being. At the curricular or programmatic level, diverse fields of study may feature economically viable professions and satisfying leisure activities that address environmental issues. Within the built environment, environmental messaging connecting students' behavior with environmental outcomes can also be framed to appeal to Egoistic values, in addition to the Biospheric values that are commonly employed throughout residence halls. Figure III.7 below shows an example of signage added to a paper towel dispenser in the bathroom. The text urges users to air dry their hands instead of using paper towels in order to "save our natural resources." While Biospheric values did positively support Materials/Waste conservation behavior ($\beta = 0.006$, $p < .05$), the language could be amended to also appeal to students' existing Egoistic values. A personally relevant frame for students in the Midwest that appeals to both Biospheric and Egoistic values might state, "Please consider using the hand dryer instead of paper towels – Save our natural resources and enjoy many more years of weekends in the North Woods!"

Figure III.7. Signage employs Biospheric values framing
Biospheric values are frequently employed in signage about environmental features in buildings. A sign affixed to a bathroom paper towel dispenser invites students to use the air dryer instead of paper towel, stating: "In order to save our natural resources, please consider using the hand dryer instead of paper towels." [Photo by author.]

Motivations: While the Self-interest motive is not significantly associated with increased ERBs in the present study, the ubiquity of Self-interest across undergraduate students suggests this might be a fruitful motive to leverage in favor of boosting ERBs. The motive of Self-interest is conceptually distinct, yet adjacent to Egoistic values. At the root, both are concerned with activities and opportunities to benefit the self. While Egoism values materiality and social influence, Self-interest is concerned with building competencies and experiences. The Self-interest motive is composed of items indicating students' desire to build skills, try new things, and improve their outlook on life. Connecting these desires to a variety of environmentally responsible behaviors could prove useful for promoting ongoing ERB in campus residence halls. Programmatic initiatives in residence halls could include skill-building workshops on composting, small-scale urban farming, and making use of re-used materials. At a design level, the built environment may support these endeavors through the provision of space for students to garden small plots of land, to tend to compost piles, and to store materials for maker workshops. Without the physical space to provision these tasks, programming may be ruled out before ever implemented.

Environmental Concern emerges as a broad, yet highly coherent (α = .938) motivation for undergraduate students in this study. Items in this factor include traditional environmental stewardship behaviors (e.g., help restore natural areas, care for the land, protect natural places from disappearing), as well as motivations to improve the environment for the benefit of others, and to explore new, personally relevant, aspects of environmental stewardship (e.g., find new ways to avoid waste, learn about my surroundings, chance to be outdoors). This environmentally-driven, yet curious, motivation to participate in activities to benefit the environment suggests students associate multiple embedded benefits with time spent outdoors and specifically, doing activities that have significant impact on the natural world.

Environmental Concern significantly predicts improved behavior with respect to Water conservation, Materials/Waste conservation, and ERB Overall. However, Environmental Concern does not appear to be associated with students' reported Energy and Travel behaviors. One possible explanation for this discrepancy is the degree to which different suites of behavior actively connect with one's conception of the natural world. As environmentally responsible behaviors, activities pertaining to water and material disposal involve a tangible connection between person and resource. Water can easily be seen, felt, heard, and tasted. Materials and waste are objects that invite a behavioral response – to be picked up, to be organized, to be disposed of. In activities that consume energy or involve traveling from one place to another, the resource being consumed is intangible. When turning on a light, one only sees the product of the resource in use; one does not actually see the electrons coursing through the wires or the fossil fuels being burned in their activation. Energy, both in interior environments and in travel, is largely invisible.

Given that Environmental Concern is a significant motivator for students to improve their Water and Material/Waste behavior, there are likely opportunities in campus residence halls to connect this existing motivation with Energy and Travel behaviors. A number of studies on feedback mechanisms have investigated the effectiveness of providing information about one's consumption of energy for reducing energy consumption. In this context, feedback about energy use serves as a proxy for tangibly experiencing energy consumption. Applied in residence halls, feedback provided via electronic dashboards located in central areas is often displayed intermittently, interspersed among campus announcements about social and academic offerings.

Empirical research on using feedback in residence halls is tenuous, as previously described. Feedback interventions are time limited, providing little insight as to the long-term durability of behavior change cultivated using feedback. Additionally, information-rich feedback can become attentionally fatiguing over time, resulting in diminishing behavioral returns as users grow mentally tired from processing complex information (Ham & Midden, 2010). College students, in particular, are especially prone to suffer from mental fatigue, as the prolonged sustained focus needed to pay attention in lectures or think about complex ideas will ultimately result in attention fatigue. Thus, highly detailed feedback systems may not be appropriate for college students unless they are able to access the information at a time when they are mentally prepared to digest it.

The application of ambient persuasive technology might be useful for students in university residence halls. Ambient persuasive technology is a form of feedback that simply directs user behavior by giving subtle information about real-time energy consumption via an interface of changing colors. Glowing green might represent efficient energy consumption, while warmer colors indicate inefficient energy practices. No other information is typically provided and therefore, ambient persuasive technology requires little cognitive effort (Ham & Midden, 2010). Implementing this type of technology in each dorm room might prove too costly to be practical; however, there are a number of small residential products that could possibly be effective in the residence hall setting[14]. Ultimately, Environmental Concern is highly motivating for undergraduate students to engage in ERBs. Finding innovative ways to make every day

14 Energy technology company, Ambient, markets several persuasive products for use in the residential sector. The Energy Orb is a frosted-glass ball that easily communicates feedback about desirable energy consumption behavior via an effortlessly understandable pleasurable green glow (Ambient Devices Inc., 2014).

energy consumption visible and tangible may be the key to connecting energy behaviors to students' concerns for the environment.

Students motivated by opportunities to engage with Technology report greater ERB Overall, as well as greater Energy and Materials/Waste conservation behaviors. These results suggest that enhancing students' exposure to technology related to energy and resource conservation in residence halls may be highly effective for improving their ERB overall. For all students, opportunities to use technology and gadgets may entice additional participation in ERBs, as students are drawn to explore the technology and discover satisfaction in participating in the behavior. While many green buildings are increasingly shifting toward automated functions, students may require an additional sense of control and exploration. Applications may include not only operable light switches, but dimmers; various forms of energy feedback technology (as described above); programmable thermostats; shower meters and timers; and trash and recycling compacters.

Gender: Males consistently report lower ERBs than females, and these differences are significant for Energy, Materials/Waste, and ERB Overall. Evidence of gender differences with respect to ERBs is consistent with findings reported in other empirical studies (Brick & Lewis, 2016; Stern, Dietz, & Kalof, 1993). However, the reason for gender differences underlying divergent environmental behaviors is unclear. Stern et al. (1993) suggest that gender differences with respect to environmental actions are not due to any inherent disparities in the values held by females and males. Rather, Stern proposes gender differences are attributable to significant dissimilarities between females' and males' beliefs about the consequences of (in)action, and that this awareness of consequences affects the relationship between one's values and actions.

While the present study did not measure participants' awareness of consequences, the data suggest that significant differences among genders with respect to values and motivations may be responsible for differences in ERBs. To test this hypothesis, this researcher conducted an Analysis of Variance (ANOVA) with post-hoc Tukey tests to identify differences among males, females, and students identifying as non-binary with respect to Climate Change Awareness, the three values orientations (Biospheric, Social, Egoistic) and five motivational clusters (Environmental Concern, Self-concern, Participate in Society, Technology, and Spirituality) included in the study. The results reveal significant discrepancies between males and females with respect to their values and motivations; these results contradict the findings of Stern et al. (1993). Students who identify as non-binary or gender fluid do not differ significantly from either males or females on any of the values and motivations measured in the study[15].

Differences between male and female reported values and motivations have important implications for their level of ERB within residence halls. Males report significantly lower Biospheric values (M=64.22, SD=20.59) than females (M=71.39, SD=17.71); $t(348)=-3.42$, $p=.001$ and lower motives related to Environmental Concern (M=57.16, SD=20.48) than females (M=64.69, SD=19.32); $t(348)=-3.43$, $p=.001$. Males also report statistically significant lower Social values (M=59.91, SD=19.19) than females (M=68.07, SD=15.50); $t(349)=-4.34$, $p=.000$ and lower motives to Participate in Society (M=69.57, SD=17.35) than females (M=76.13, SD=15.07); $t(349)=-3.71$, $p=.000$. Of these traits, Biospheric values and being motivated by

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15 One statistically significant difference between non-binary and female students was detected. Females reported their Motivation to Participate in Society to be an average of 20 points higher than non-binary students ($p<.01$). However, only six students identifying as non-binary completed the survey items for the Participate in Society motivation compared to 257 females and therefore the validity of this result is doubtful.

Environmental Concern are both compatible with higher levels of ERBs in undergraduate students. Egoistic values, for which males report significantly higher scores (M=67.09, SD=17.19) than females (M=61.21, SD=19.26); t(349)=2.86, p=.005, are significantly associated with poorer performance in all behavior categories except students' travel behavior. Males also perform significantly poorer in the majority of the behavior categories, including Energy, Materials/Waste, and ERB Overall. However, males do report stronger motivations by Technology (M=68.52, SD=22.35) than females (M=57.11, SD=23.71); t(347)=4.41, p=.000), which is significantly associated with positive ERBs in Energy, Materials/Waste, and ERB Overall. The only value or motivation measured on which Males do not significantly differ from females is the motive of Self-interest, suggesting that among undergraduate students this motive is fairly consistent across genders.

Together, these results shed light on some of the possible explanations underlying the poorer performance of ERBs by males in undergraduate residence halls. Two traits are particularly worthy of focus: Egoistic values and the Technology motive. Males report significantly higher scores than females on both of these characteristics. While Egoistic values have been consistently associated with lower levels of ERB, the environment may be adapted (as previously described) to better support desirable behavior by successfully leveraging existing values in favor of ERB. The Egoistic value cluster is composed of items emphasizing one's ability to earn a high salary, to acquire desired material possessions, and to have influence among one's social group. This value cluster is particularly well-aligned to traditional gender norms about male responsibility to be the "breadwinner" or provider. While contemporary college students may not overtly identify with the traditional gender norms of older generations, gender expectations nonetheless may explain the difference between males and females with respect to Egoistic values. Additionally, males are significantly more motivated than females by opportunities to use new technology or try new products. This motive to interact with Technology also significantly predicts improved Energy behavior, Materials/Waste behavior, and ERB Overall. Yet despite having a more favorable disposition toward technology, males report significantly poorer behavior in each of these behavior categories. Thus, providing more opportunities for students, and males in particular, to interact with technology or gadgets in the pursuit of conserving energy and resources may prove effective for improving ERBs overall.

Contextual Dimensions of ERB in Residence Halls

Green Buildings, Brown Occupants? The results suggest that green residence halls do not unilaterally offer more supportive behavior settings for undergraduate students' ERBs. In aggregate, students living in green residence halls do not engage in more environmentally responsible behaviors than their counterparts in conventional residence halls. Students living in green halls performed only minimally better than students in non-green halls with respect to Water conservation behavior but reported poorer performance of ERBs in every other category, including a significantly lower score in conservation of Travel behavior. There are a few possible justifications for this finding. It is possible that students who chose to live in green residence halls evaluated their own behavior more conservatively due to a higher standard of sustainability, and therefore perceived their conservation behavior to be inferior. Inversely, students living in conventional residence halls, perceiving their building to contribute very little to environmental sustainability, may have evaluated their own ERBs higher within the context of their building.

Another possible explanation for why ERB in green buildings did not surpass ERB in conventional buildings is that green buildings and conventional buildings offer different opportunities for residents to participate in ERBs. Many of the features with which occupants would typically interact to control the environmental conditions within their residence hall (light switches, thermostats, and faucets) are less available for control by students in green buildings. As sustainable buildings have shifted dramatically toward increasing automation (Castle, 2011; Murtagh et al., 2015; Vagia, Transeth, & Fjerdingen, 2016), fewer environmental and resource controls are within the direct purview of occupant. For example, building A.2 contains motion-activated faucets and light switches, while these same functions in A.3, the conventional residence hall, are entirely manually operated. Without disregarding the energy and resource savings accomplished by motion-activated features, the behavioral effects of inhabiting spaces that require little to no occupant participation in order to conserve resources remain uncertain. However, it is reasonable to expect that repeatedly not having to think about turning off the water while brushing one's teeth or not turning off the lights when leaving an unattended common room may have negative consequences on students' long-term habitual behaviors. Future research is needed to analyze whether environments that permit occupants greater control over the building's resource consumption are associated with improved ERBs.

Behavior in Buildings over Time: Lastly, the results pertaining to RQ3 demonstrate marginal improvement in ERBs over time when considering the entire sample of students across all six residence halls. This aligns with expectations - as previously noted, undergraduate students are increasingly immersed within a whole-system designed to emphasize sustainability on college campuses. The finding of improved environmental behaviors is a new contribution to the literature that has previously documented improved environmental stewardship reasoning and knowledge among undergraduates from campuses with a university-wide commitment to sustainability (Brodrick Hartman et al., 2017). However, this study revealed only statistically significant behavioral improvement from T1 to T2 in the category of Materials/Waste conservation.

Upon further investigation of the change in ERBs from T1 to T2 in individual residence halls, one residence hall actually reported poorer behavior scores in every behavior category over time: A.2, the newest green building at University A. The largest declines in behavior between T1 to T2 occurred in the Energy and Water conservation categories. Students living in A.2 reported the largest discrepancies between Water behavior changes over time compared to students living in A.3 and B.3, the two conventional buildings in the study. Informal observations of the water features in these buildings suggests there may be a contextual influence specific to building A.2 impacting students' water consumption. It has already been noted that A.2 has motion-activated sink faucets. Additionally, A.2 is the only building that offers truly private bathrooms. In contrast to B.3, which has a private bathroom within each shared bedroom, A.2 has individual bathrooms available per every five to six rooms. In addition to the issue of automated versus manual control over water consumption, there may be an effect of a lack of social norms influencing increased water consumption in building A.2. In a communal bath and shower room, students negotiate shower and sink use with the demands of other students who may be physically present, waiting to use these resources. Even in B.3, a student has access to private bathroom within their room but is still accountable to their roommate who may be waiting immediately inside the bedroom for their time in the shower. In contrast, students in A.2 have access to a completely private bath and shower room that is physically separated from their dorm room. The arrangement of space and allocation of private bathrooms that release students from social obligations to conserve time in the bathroom (and therefore water consumption) is possibly responsible for the increase of water consumption over time in A.2. Considering the overall decline of ERBs over time in building A.2, future analyses are necessary to examine how building- and feature-specific contexts shape students ERBs. It is possible that the greenest buildings create behavior settings that foster the *brownest* behavior.

Limitations

One of the limitations of this study, and of comparative case study research in general, is the ability to make comparisons between sites that are not congruent. This posed a challenge in the present study as no two residence halls within the same university, let alone on different campuses, are identical. Aside from the physical differences in layout, materials, and site selection, the social atmosphere of each building and campus is shaped by the unique individuals who inhabit each setting. Despite these challenges, the researcher selected the case studies in order to maximize comparison among the residence halls.

The methodology used in this study relied on self-report data about individual behavior. A challenge in all survey research, this researcher attempted to minimize social desirability bias in participant responses by distributing the survey online and collecting no personal identifiers. Future behavior measures could be more robust by including observations, collecting energy and resource consumption data at the building or floor level, or having participants keep behavior logs.

The time between the fall (T1) and spring (T2) survey administration ideally should have been longer and might have included an additional mid-year evaluation. The gap between the two data points was only five months because both universities planned to launch a campus-wide sustainability competition based in the residence halls during the spring semester. Thus, the spring survey was launched and collected before advertising for these competitions began so as not to introduce bias into the students' responses.

Lastly, there is the perennial concern about self-selection. It would be ideal to have been able to randomly assign incoming students to the various residence halls. Unfortunately, in this study, the majority of first-year residents were able to self-select the residence hall in which they would reside. This self-selection might have affected the findings with students who selected green residence halls being previously primed to adopt environmentally responsible behavior. To address this possibility, an analysis of variance was conducted examining the T1 survey data by residence hall. Post-hoc Tukey tests revealed that across all T1 survey instrument measures (values, motivations, and climate change awareness), there was only a single statistically significant difference. Students in building B.1 reported significantly lower motivation to Participate in Society ($M=68.41$, $SD=17.56$) than students in B.2 ($M=77.19$, $SD=13.13$); $t(122)=-3.069$, $p=.003$. While this does not eliminate the possibility that self-selection affected the findings reported here, it does reduce that prospect.

Implications

This research has important implications for the design of residence halls that support ERBs within the college-age population and for the further development of the psychology of environmental stewardship. It also contributes to the existing literature on green buildings.

1. Previous research about ERB in undergraduate residence halls has not accounted for the existing values and motivations of students. The findings presented here suggest that without addressing these personal dimensions that affect the adoption of ERBs, empirical findings from behavioral interventions will not be reliable. Furthermore, the results of this study identify several specific traits (e.g., Biospheric values, Environmental Concern motive, Technology motive, and Egoistic values) that significantly impact students' ERBs. These are traits that should be understood during the planning and design of green

buildings in order to give direction as to how to adapt the physical and informational contexts of students to be more supportive of their existing environmental inclinations.

2. Parting ways with current scholarship that employs behavioral interventions in residence halls, this study introduces the green building as an informal behavioral intervention, thus accounting for the role of *context* in shaping ERB. Daily encounters with both green and conventional buildings have the capacity to shape how students think about environmental issues and their own behavior patterns. The role of context as an informal teacher and guide needs to be actively brought into the psychology of stewardship behavior. However, perhaps the more fascinating implication concerns a possible limitation of green design on the adoption of ERBs. In this study, green residence halls do not automatically promote or support behavior change. Rather, there may be individual features within green and conventional residence halls that promote or hinder the long-term cultivation of ERB.
3. Lastly, this study begins to address the issue of durability of behavior change. This is a desirable outcome that is often neglected in formal intervention studies. Observing students' behavior over time without the intervention of a particular strategy or social competition reliably reflects the natural conditions of students' every day environmental behaviors. The evolution of behavior over time in a natural context provides a useful perspective about how students will be affected by the physical context of the spaces they encounter every day, and how durable that effect may be. This has important implications for the design of a wide range of public spaces to support environmentally responsible behaviors.

Conclusion

Undergraduate students occupy a unique transitional time in life in which new behaviors and commitments may be cultivated. This provides an opportunity to leverage the time that students have in residence halls and on college campuses to make significant environmental impacts, both in the present at the university and into the future. Green buildings have the potential to serve as educational and behaviorally supportive settings for increasing students' ecological consciousness and openness to long-term environmentally responsible lifestyles. However, the present results suggest that merely living in a green residence hall does not automatically predispose students to improve their environmental behaviors. Occupant behavior is likely less directed by a holistic awareness of their building's greenness, but rather, a product of one's existing knowledge, values, and motivations as they intersect with a series of building features that either promote or discourage occupant action. Future research is necessary to examine both green and non-green buildings at the feature-level to determine the extent to which buildings afford environmentally responsible behaviors.

CHAPTER IV

Priming, Permitting, and Inviting: An Analysis of Building Features that Support Environmentally Responsible Behaviors in Undergraduate Residence Halls

With the demand for creating more sustainable built environments, there is a critical need for better understanding how humans interact with such spaces. Extensive research has documented the benefits of living in sustainable, or green buildings, including improved indoor air quality, lighting quality, thermal comfort, and acoustic qualities (Benfield et al., 2015; Hua et al., 2014; Kelz et al., 2015; Lennon et al., 2017; Paul & Taylor, 2008; Thatcher & Milner, 2016). In addition to the advantages of occupying a green building, researchers in the field of environmental education are increasingly interested in the role of the built environment as a tool for teaching about ecological systems; contemporary environmental challenges; and technological and behavioral solutions. Thus far, this body of research has explored the built environment as an environmental educator within the context of formal educational environments, such as libraries, museums, and schools buildings (Aulisio, 2013; Barnes, 2012; L. B. Cole, 2014; L. B. Cole & Altenburger, 2017; Han & Hyun, 2017; Higgs & McMillan, 2006; Izadpanahi et al., 2017; Kostic et al., 2015). Within the context of environmental education, the relationship between the physical setting and building occupants is typically mediated by a specific environmental curriculum. Interactive exhibits, visual displays, and in-class instruction partner with green building features in an intentional and formal effort to craft educational experiences centered on sustainability for those who occupy green buildings.

A few initial studies have begun to examine the *informal* influence of the physical context of green buildings on occupant environmental behaviors; however, these have returned mixed results (Watson et al., 2017, 2015). Chapter III of this dissertation presents the results of a study that explored the ERBs of undergraduate students living in green and conventional residence halls. Several personal characteristics were found to significantly improve or impede environmental behaviors. However, regression analyses revealed no clear relationship between living in a green versus a conventional residence hall and occupant ERBs. Further, despite there being virtually no significant differences among the residence halls regarding students' reported Values and Motivations, analyses of students' behaviors by individual residence halls over time suggested students in at least one green residence hall (A.2) performed significantly poorer than did students in other halls over time, including the conventional residence halls. Moreover, even when the data from this particular residence hall were removed from the regression analyses, living in a green building still did not predict improved environmental behaviors. Taken together, these results suggest that green buildings may not universally increase occupant ERBs. However, a more detailed examination of the features within these buildings may reveal shared characteristics across green and conventional residence halls that either support or undermine environmental behaviors.

Contextual Support for ERBs in Positive Sustainable Built Environments

The second chapter of this dissertation proposed a theoretical model outlining the characteristics of built environments that likely support ERBs. The Positive Sustainable Built Environments (PSBE) model (see Figure IV.1) combines knowledge from the psychology of environmental stewardship and environment and behavior studies into a cohesive model for theorizing sustainable buildings and their potential impact on occupant environmental behaviors. A brief review of the elements of this model is necessary as a precursor to discussing how each of the domains was operationalized and applied to the analysis of the six residence halls included in the present study.

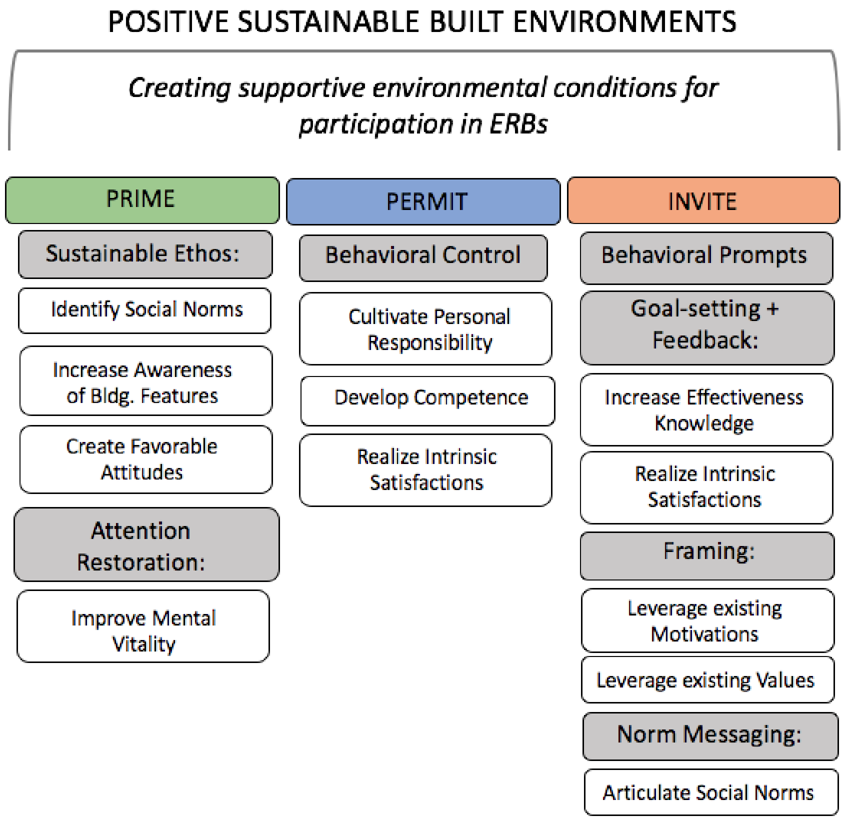

Figure IV.1. The Positive Sustainable Built Environments Model

The first domain of the PSBE model relates to how the physical context of the green building serves to *Prime*, or prepare, occupants to adopt environmentally responsible patterns of behavior. Priming behavior in green buildings may include subtle and overt means of communicating a sustainable ethos to building occupants. Environmental educator and theorist David Orr has termed this the "hidden curriculum" of green buildings (Orr, 1997), which may include the incorporation of a mixture of natural materials, indoor vegetation, and views to nature. More overtly, signage in green buildings is frequently used to draw attention to sustainable building features, conveying a message of institutional commitment to sustainability. Additionally, buildings may prime occupants to adopt sustainable patterns of behavior by providing the physical environments that support mental vitality. Mental vitality is associated with the ability to solve problems, make plans, and monitor one's behavior (De Young, 2010) – all of which are skills compatible with adopting and committing to long-term patterns of environmentally responsible behavior. At its core, mental vitality can be characterized as the ability to direct one's attention, or focus. However, this seemingly simple task requires significant cognitive effort. From a cognitive psychology perspective, all of human functioning relies on two forms of attention. Directed attention is finite and fatigues over time. Conversely, involuntary fascination allows humans to effortlessly orient their attention toward innately fascinating stimuli (e.g., loud noises, sudden movement, food, water, fire, etc.). The fatigue of directed attention cannot be physically felt but is evident in a number of observable behavioral patterns: irritability, difficulty processing abstract concepts, inability to inhibit socially inappropriate behavior, and decreased likelihood to engage in helping behaviors. Fortunately, the recovery of directed attention is fairly easy. Attention restoration simply requires the rest of directed attention through the engagement of involuntary fascination (Rachel Kaplan & Kaplan, 1989c; Stephen Kaplan, 2001). Nature is a frequently cited aspect of environments that support attention restoration because natural elements tend to be effortlessly engaging and a wide range of exposure to nature can be restorative. In the built environment, research has shown that even nature enjoyed briefly—such as the view out a window or indoor plants—are beneficial for reviving a tired mind (R. Kaplan, 2001; Raanaas, Evensen, Rich, Sjøstrøm, & Patil, 2011; Tennessen & Cimprich, 1995). A building that provides access to nature on the interior and exterior of the building is thought to *prime* occupant ERBs by affording opportunities for attention restoration and thus restoring occupants' cognitive capacity to think about one's behavior, seek out less readily available alternatives, and to make plans for accomplishing tasks through more environmentally conscientious means.

The second domain of the PSBE model, *Permit,* addresses the extent of control and participation occupants are afforded to alter their environmental conditions and conserve resources in the built environment. *Permit* is characterized by building features that allow occupants to act upon their environment by turning off a light, adjusting a thermostat, sorting recyclables or compost, etc. The hypothesis underlying this dimension is that small behaviors carried out through the day can become habitual and transferrable to other settings. Cultivating the habit of turning off unnecessary light sources cannot occur if the environment does not afford occupants the opportunity to turn off the lights. Consequently, just as positive behavioral patterns can be nurtured in an environment that supports these behaviors, so can unsupportive environments breed apathy and patterns of behavior in which simple acts, like turning off the lights, gradually dissolve from practice.

Invite, the third domain of the Positive Sustainable Built Environments model, draws from the literature of environmental stewardship in which empirical studies document a number of strategies that elicit behavior change at the individual and community level. Behavioral intervention programs designed to target a wide range of psychological and social factors through a variety of strategies have yielded the most generalizable results for organizations working with individuals and small groups to change environmental behaviors (Abrahamse et al., 2005). In the built environment context, the quantity and diversity of behavioral intervention features are similarly hypothesized to support environmentally responsible behaviors.

Methods

Chapter III partially addressed the role of the physical context in shaping students' ERBs. The results demonstrated that the greenness of a student's residence hall was not significantly related to their environmentally responsible behaviors. However, differences among the individual residence halls revealed strong trends in students' behavior over time, suggesting there might be environmental or other characteristics unique to each hall that impact student behaviors. The present study examines the contextual dimensions of ERB in more depth (see Figure IV.2). This chapter applies the Positive Sustainable Built Environments model to a visual content analysis of the six undergraduate residence halls and explores the following research questions:

Research Question 1 (RQ1): Are the building characteristics of on-campus residence halls, according to the PSBE model, associated with undergraduate ERBs in the categories of Energy, Water, Materials, and Travel[16]?

Research Question 2 (RQ2): Are the previously identified trends in behavior over time among the residence halls (reported in Chapter III) consistent with the residence halls' scores in each of the PSBE domains?

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16 ERB was divided into four categories of behavior, derived from the dominant categories in the LEED® certification system with the most directly identifiable impacts on occupant behavior: Energy, Water, Materials, and Travel. Occupants completed an online survey, in which they self-reported their typical behaviors in each of these categories. The results from this survey (completed in Fall 2016 and Spring 2017) are discussed in depth in Chapter III.

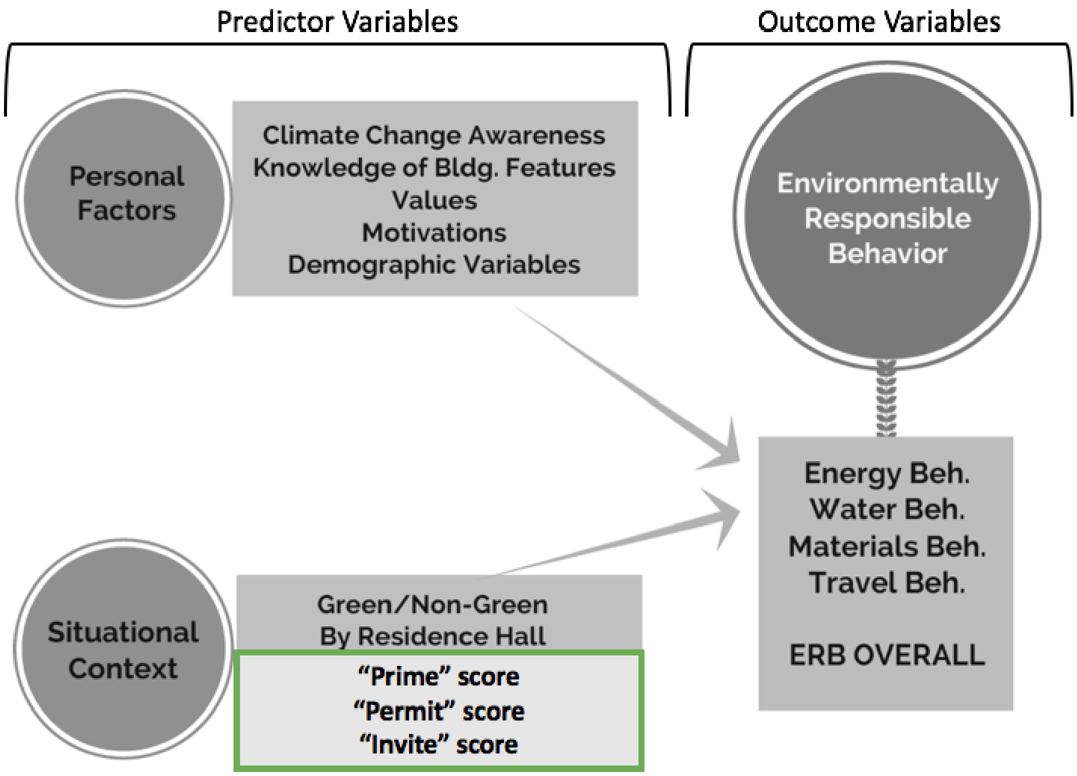

Figure IV.2. Conceptual Diagram of Research Design, Chapter IV
Chapter IV examines the impact of the situational context of green and conventional residence halls on occupants' environmentally responsible behaviors. Where Chapter III evaluated the situational context at the level of if the residence hall was a green or conventional building, Chapter IV evaluates the residence halls on three categories of ways a building may support ERB. These categories of building characteristics are derived from the Positive Sustainable Built Environments model: Prime, Permit, and Invite.

Participants and Settings

The study includes six undergraduate residence halls from two universities in the Midwest United States (University A and University B). Of the three residence halls from each campus, two halls have achieved or met LEED® Gold certification (A.1, A.2, B.1, and B.2) and one residence hall is a conventional building (A.3 and B.3). Although built in different decades, each of the halls affords students many of the same amenities in terms of physical space and opportunities for social interaction. All provide shared rooms with additional communal spaces for lounging, socializing, studying, and laundry facilities. Restroom and shower facilities are predominantly shared by several students in the traditional style of a common room with several shared sinks, toilets, and shower stalls. However, two halls offer students different versions of a private bath. Hall B.3, a converted campus retreat center, has in-room bathrooms shared by two students only. Hall A.2 affords a semi-private arrangement consisting of four smaller single-user bathrooms with a single sink, toilet, and shower stall, per every six rooms.

The participants include 575 undergraduate students, with an average age of 19 years, who were all first-time residents of their on-campus residence halls during the 2016-2017 academic year. Students were invited to complete an online survey about their everyday environmental behaviors two times during the school year. In total, 388 students took the survey at Time 1 (T1; Fall 2016 semester) and 187 students took the survey at Time 2 (T2; Spring 2017 semester), for response rates of 23.6% and 11.4% respectively. Fifty-four students took the survey in both the Fall and Spring semesters.

Personal and Contextual Dimensions of ERB

Results from the online surveys were used to assess the personal antecedents of students' environmental behaviors in four categories: Energy, Water, Materials, and Travel. The psychological dimensions of behavior that were measured included: Climate Change Awareness, dominant Value orientations (Biospheric, Egoistic, and Social), Motivations (Environmental Concern, Self-Interest, Participation in Society, Technology, and Spirituality), and students' perceived and actual knowledge of conservation building features relevant to each of the behavior categories. The full analysis and discussion of these results can be found in Chapter III.

In addition to the personal factors that influence environmental behaviors, the study in Chapter III also examined the overall impact of living in green versus conventional residence halls. While the results revealed no clear[17] relationship between the greenness of the building and students' ERBs, several features across the residence halls suggested potentially different impacts on occupant environmental behaviors. Variability among these features produce living environments that differ with respect to the overall impression of environmental sensitivity or connectedness to nature experienced in each residence hall, the amount of control and choice over the interior environmental conditions afforded to students, and how actively elements in the environment are used to promote ERBs. Respectively, these categories of features represent the *Prime, Permit,* and *Invite* domains of the Positive Sustainable Built Environments model and are the focus of the present study.

Documentation of Building Features

The physical context of the residence halls was documented during campus visits during October 2016. The researcher was accompanied by a campus representative and allowed access to all spaces that would typically be accessible by student residents. Photographs were taken frequently to capture the full visual[18] experience of dwelling within and moving through the residence halls. Approximately 200 images were taken for each residence hall, capturing a thorough representation of student-accessible spaces on the interior and near exterior of the

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17 Only for Travel behavior did the greenness of the residence hall significantly impact students' behavior, resulting in a lower conservation score than for students living in a conventional residence hall. The relationship between building greenness and ERBs was not significant in the other measured behavior categories and resulted in both positive and negative behavioral trends. See Chapter III for the full results of the linear mixed effects regression analyses.

18 The method of documentation and analysis used in this dissertation biases visual perception within a typical range of function. While other modes of sensory input contribute to one's comprehensive experience of a space, this study relied solely on visual information. Future research could explore features in built environments that influence occupants' experience of the sustainability of a building through auditory, tactile, or other cues.

building. Between one and three student rooms were made available for photo documentation in each residence hall. The location of the photographer and direction of the view were recorded by hand on two-dimensional building plans and given an image code corresponding to the building, floor level, and sequential order of the photograph (e.g., A1.1.23). Figure IV.3 shows a section of a building plan with the location of the photographs marked and coded.

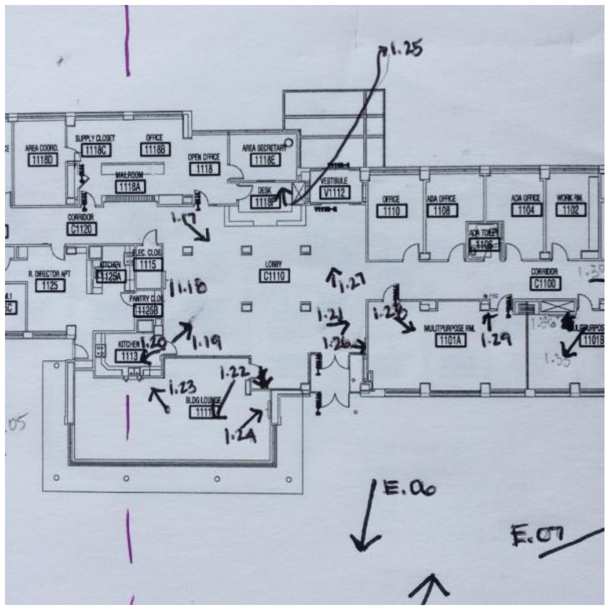

Figure IV.3. Documentation of Photograph Locations

The photographs were next separated into groups by category of space per residence hall. The kinds of spaces afforded to students in each building were fairly consistent, resulting in 12 spaces distinguished by primary function: building exterior, lobby interior, special event lounges, kitchens, computer room, laundry facilities, hallways, resident lounge/TV areas, resident study rooms, trash/recycling rooms, bath/shower rooms, and bedrooms. In total, there were only three instances in which a residence hall did not have one of the previously listed spaces. Halls A.3 and B.1 provide spaces for resident lounge activities but did not have a dedicated special event lounge within the residence hall portion of the building[19]. Additionally, B.2 lacked a computer room. Occasionally a residence hall included an additional space that the other five residence halls did not include. Hall B.2 included a working greenhouse and bicycle repair shop; in this instance, these specialty spaces were classified as special event lounges. Representative images of the spaces were then chosen for each residence hall. On average, four images per space (range: 2-8) were selected to depict a holistic impression of occupying the space. See Table IV-1 for an inventory of spaces in each residence hall.

Table IV-1. Space Inventory by Residence Hall

	RESIDENCE HALLS					
SPACES	A.1	A.2	A.3	B.1	B.2	B.3
Building Exterior	✓	✓	✓	✓	✓	✓
Main Entrance/Lobby Interior	1	1	1	1	1	1
Special Event Lounges	6	2	0	0	3	1
Kitchen	2	1	1	1	5	1
Computer Room	2	1	1	1	0	1
Laundry	2	1	1	1	1	3
Hallways	✓	✓	✓	✓	✓	✓
Resident Lounge/TV	22	16	1	4	5	7
Resident Study Room	14	12	7	8	4	5
Trash/Recycling	9	4	23	4	4	4
Bath/Shower Room	76	178	18	54	21	79
Bedrooms	270	262	230	212	92	76
GREEN BUILDING?	LEED Gold	LEED Gold	N/A	Meets LEED Gold	LEED Gold	N/A
YEAR OPEN	2013	2016	mid-1950s	2012	2013	1959
# RESIDENTS	461	491	455	440	171	140
# FLOORS	6	5	5	5	5	5

Note: Halls shaded in green are LEED® certified or meet the same standards. Halls shaded in yellow are conventional halls.

Operationalizing the Positive Sustainable Built Environments Model

The Positive Sustainable Built Environments model was translated into identifiable features via the creation of a scoring guide (See Table IV-2). For each of the 12 spaces per residence hall the domains *Permit* and *Invite* were assessed within the context of the behavior

19 Hall B.1 contains a dining hall that was not included in the current study on residence hall design. A few special events lounges were available in the dining facilities section of the building.

categories of interest in this study: Energy, Water, Materials, and Travel. More specifically, *Permit* characteristics were defined as ones that allow occupants to perform an environmentally responsible action; and *Invite* characteristics demonstrated an intentional attempt to encourage an environmentally responsible behavior. All four behavior categories were considered in every space as building occupants could occasionally engage in multiple categories of behavior within a single environment. For instance, Energy, Water, and Materials behaviors may all take place in the bathroom if students are afforded opportunities to turn on/off the lights, adjust a thermostat, open windows, operate a dual flush toilet, and compost their used paper towels. In contrast, the *Prime* domain of the PSBE model was not assessed per behavior category, but holistically by space alone. This decision was made because the *Prime* domain pertains to creating the conditions under which people are cognitively capable of participating in ERBs broadly; characteristics in this domain are not thought to specifically prime behavior in only one particular category.

Table IV-2. Positive Sustainable Built Environments Scoring Guide

PSBE Domain	0 - None	1 - Low	2 - Medium	3 - High
PERMIT	*No action available*	*Only 1 way to engage in ERB*	*2 ERBs available*	*3 or more ERBs available*
Energy	Light switches, multiple switches for areas of the room; manual override for motion-activated lights; dimmers; multiple levels of lighting and adjustability (ambient, task, accent); adjustable thermal comfort conditions (thermostat or window units); television controls; shades on windows/blinds; operable windows; adjustable temp settings on washers or dryers			
Water	Manual faucets turn on/off; dual flush toilets; adjustable water settings on washers			
Materials	Trash/recycling/compost bins; multi sort recycling versus single sort; water bottle filling stations; places to gather donated items for reuse			
Travel	Bike racks; pedestrian paths; bus stops; perceivable proximity to amenities			
INVITE	*No attempt to shape behavior*	*Only 1 strategy implemented*	*2 strategies implemented*	*3 or more strategies implemented*
Energy	Energy dashboard (provides feedback in form of declarative information, could include procedural guidance, social competition, goal-setting); prompts to turn off lights			
Water	Posted signage to turn off water while brushing teeth/washing hands (prompts); information about dual flush toilets (procedural information about how to use, possible values framing); timers in showers (norm setting, goal-setting and feedback)			
Materials	Number of bottles saved from landfill on water bottle fillers (feedback, values framing); Posted signage: "Using hand dryer saves X trees per use" (effectiveness knowledge connects behavior to environmental outcome)			
Travel	Covered bike racks outside (situational convenience); Posted bus schedules (procedural); ride share signage (procedural info + social norms); Bike repair station (situational convenience, procedural information); persuasive pathways (mystery, sensory)			
PRIME	*None*	*Low*	*Medium*	*High*
Sustainable Ethos + Information	Natural materials; mixture of materials; natural motifs; natural features (indoor plants, water features, etc.); recycled or repurposed materials/finishings; Providing declarative information about the sustainability of a feature: Energy star sticker; LEED® seal, "Made from recycled laundry detergent bottles"			
Attentional Capacity	Window/views to outdoors; views of nature; places for reflection (walking paths, etc.); natural light			

Photographs were scored on a 0-3 scale in each of the three PSBE domains. For the *Permit* and *Invite* domains, the numbers on the scale corresponded to a quantitative assessment of the number of features identified per behavior category. For the *Prime* domain, the score corresponded to a qualitative assessment (i.e., none, low, medium, high) of the visible characteristics, relative to the other comparable spaces. *Prime* characteristics, such as size of windows and amount of visible nature, are challenging to quantify, so a qualitative approach was adopted to assess each space. The scoring sheet is shown in Figure IV.4.

	Energy		Water		Materials/Waste		Travel		PRIME
	PERMIT	INVITE	PERMIT	INVITE	PERMIT	INVITE	PERMIT	INVITE	
Public Spaces									
Building Exterior									
Main Entrance/Lobby Interior									
Semi-Public/Private Spaces									
Special Event Lounges									
Kitchen									
Computer Room									
Laundry									
Hallways									
Resident Lounge/TV									
Resident Study Room									
Trash/Recycling									
Bath/Shower Room									
Private Spaces									
Private Bedroom									

Figure IV.4. Visual Content Analysis Scoring Sheet
Scores from each domain per room are recorded on the Visual Content Analysis Scoring Sheet. One Scoring Sheet is completed for each residence hall.

Data Analysis

Building feature variables were created by calculating the statistical mean of the scores across all 12 spaces, within each behavior category and PSBE domain. As previously noted, the *Prime* domain was not analyzed according to behavior category, thus a single *Prime* score was calculated by the mean of the scores from all of the spaces. This process resulted in eight final building feature variables with different values per each residence hall: Energy_Permit, Energy_Invite; Water_Permit[20]; Water_Invite; Materials_Permit; Materials_Invite; Travel_Invite[21]; and Prime.

To account for the impact of social interaction and observation of others' actions on one's behavior, this study originally classified the spaces into different strata of social influence. Because aspects like territory, privacy, perceived and actual control, and visibility of social norms vary within the continuum of public to private spaces, it was expected that variability among the social levels (Public, Semi-Public/Semi-Private, and Private) would yield observable differences in how features affording occupant control or restorative views to nature are dispersed throughout a residence hall. In order to analyze the building features according to level of social influence, this would have necessitated splitting each building variable into three variables instead of one (e.g., Energy_Permit_Public, Energy_Permit_Semi-Public, and Energy_Permit_Private). Ultimately, the data did not have the power to support this added number of variables and the consideration of social levels was removed in favor of the method described above consisting of the mean score across all spaces. The interaction among social spaces, perceived authority, and territory are worthy of consideration in future studies.

The data analysis used a linear mixed-effects regression (LMER) procedure to explore the fixed effects of the building characteristics on occupants' environmentally responsible behaviors in four categories: Energy, Water, Materials, and Travel behaviors. The building

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20 Water_Permit and Water_Invite are comprised of only the scores generated for the bathroom spaces. All the other spaces across all six residence halls received the same scores and this lack of variability in the scoring obscured the actual variability present in the bathroom spaces.
21 Travel_Permit was eliminated from the final collection of building variables because the scores per spaces were identical across all six residence halls. Without variability in the data, this building variable would be useless in predicting occupant behavior.

variables were added into the regression models developed previously in Chapter III, retaining the same personal variables (Climate Change Awareness, Values, Motivations, and Knowledge of Building Features) and using the outcome variables of Energy, Water, Materials, and Travel Behaviors. Participant ID was entered as a random effect, accounting for the correlation between the scores of the 54 students who took the survey at both T1 and T2. However, variables for Residence Hall and Building Greenness (0 = conventional, 1 = green) were removed from the LMERs due to multicollinearity with the building feature variables of interest in this study. The resulting regression models closely resemble those from the previous study, except with the three additional building variables, corresponding to the three domains of the Positive Sustainable Built Environments model: *Prime*, *Permit*, and *Invite*.

Results

This study was concerned with two research questions (RQs): if the three domains of the Positive Sustainable Built Environments Model (*Prime*, *Permit*, *Invite*) are significantly related to environmentally responsible behaviors across residence halls (RQ1); and if the previously identified trends in behavior over time are consistent with the residence halls' scores in each of the PSBE domains (RQ2).

RQ1: Significance of the PSBE Domains for Predicting Occupant ERBs

The building characteristics evaluated in this study (*Prime, Permit, Invite*) are listed in the last three rows of the regression results in Table IV-3. (Two of the three domains of the Positive Sustainable Built Environments model were significantly associated with occupant ERBs. The *Prime* domain was found to be the most supportive of occupant ERBs, significantly predicting improved conservation behavior in two of the four behavior categories. Energy conservation behavior was improved on average by 8% in an environment with a one-point increase in its assessment to *Prime* occupants' capacity to participate in ERB ($\beta = 0.585$, $p < .01$). Similarly, Water conservation behavior improved at a similar magnitude with a building's increased *Prime* score ($\beta = 0.571$, $p < .05$). However, contrary to expectations, a building's *Permit* scores revealed no consistent relationship with occupant ERBs. A residence hall's *Permit* score was nearly significantly associated with students' Materials conservation behavior, though not in the expected direction; higher *Permit* scores were associated with lower Materials conservation behavior ($\beta = -0.723$, $p = .053$). Lastly, the *Invite* domain was effective in predicting one behavior category; materials conservation behavior was higher in buildings with features that actively invited conservation of materials and the responsible disposal of waste ($\beta = 0.383$, $p < .01$).

Table IV-3. Significance of Building Characteristics in Predicting ERBs in Undergraduate Residence Halls – Linear Mixed Effects Regression Models

		ENERGY BEHAVIOR			WATER BEHAVIOR			MATERIALS BEHAVIOR			TRAVEL BEHAVIOR		
	Variable	Estimate	t-statistic	p-value	Estimate	t-statistic	p-value	Estimate	t-statistic	p-value	Estimate	t-statistic	p-value
	Intercept	2.055	2.312	0.022	3.302	5.958	0.000	3.852	6.08	0	3.725	6.701	0.000
Gender	Male	- 0.205	- 2.144	0.033 *	- 0.184	- 1.991	0.048 *	- 0.303	- 3.478	0.001 **	- 0.059	- 0.708	0.480
	Non-binary	0.235	0.639	0.523	0.172	0.500	0.617	0.034	0.107	0.915	0.194	0.627	0.531
	Female	0[a]	.	.	0[a]	.	.	0[a]	.	.	0[a]	.	.
Major	Social Science and Humanities Majors	0.170	0.734	0.463	- 0.165	- 0.733	0.464	- 0.079	- 0.386	0.699	0.031	0.152	0.879
	STEM/Business Majors	0.030	0.132	0.895	- 0.140	- 0.638	0.524	- 0.030	- 0.154	0.878	0.041	0.202	0.840
	Environmental Fields	0[a]	.	.	0[a]	.	.	0[a]	.	.	0[a]	.	.
Year In School	1st Year	--	--	--	--	--	--	0.742	1.998	0.047 *	- 0.477	- 1.413	0.159
	2nd Year	--	--	--	--	--	--	0.690	1.85	0.066	- 0.425	- 1.249	0.213
	3rd Year	--	--	--	--	--	--	0.819	2.009	0.046 *	- 0.118	- 0.311	0.756
	4th Year	--	--	--	--	--	--	0.226	0.513	0.609	- 0.160	- 0.381	0.703
	5th+ Year	--	--	--	--	--	--	0[a]	.	.	0[a]	.	.
Survey Time	Spring	0.110	1.401	0.163	0.161	2.316	0.022 *	0.162	2.641	0.009 **	- 0.005	0.072	0.943
	Fall	0[a]	.	.	0[a]	.	.	0[a]	.	.	0[a]	.	.
	Biospheric Values	0.002	0.532	0.595	0.004	1.391	0.165	0.006	2.106	0.036 *	0.003	1.118	0.265
	Social Values	- 0.001	- 0.396	0.692	- 0.003	- 0.814	0.416	0.000	0.065	0.948	0.000	- 0.019	0.984
	Egoistic Values	- 0.009	- 3.310	0.001 **	- 0.006	- 2.285	0.023 *	- 0.008	- 3.618	0.000 ***	- 0.003	- 1.100	0.272
	Environmental Concern Motive	0.005	1.397	0.163	0.008	2.129	0.034 *	0.007	2.092	0.037 *	0.000	0.114	0.909
	Self-interest Motive	0.001	0.298	0.766	- 0.002	- -0.530	0.596	- 0.002	- 0.590	0.556	- 0.004	- 1.301	0.194
	Participate in Society Motive	- 0.001	- 0.170	0.865	- 0.009	- 2.396	0.017 *	- 0.004	- 1.268	0.206	0.004	1.175	0.241
	Technology Motive	0.005	2.359	0.019 *	- 0.002	- 0.943	0.347	0.006	3.259	0.001 **	0.002	1.391	0.165
	Spirituality Motive	- 0.001	- 0.447	0.655	0.001	0.492	0.623	0.003	1.310	0.191	0.004	1.805	0.072
	Climate Change Awareness	0.070	0.981	0.327	0.125	1.825	0.069	0.062	0.975	0.330	0.003	0.048	0.961
	Perceived Knowledge of Conservation Building Features[bc]	0.155	2.935	0.004 **	0.066	1.546	0.123	0.040	1.106	0.270	0.247	5.363	0.000 ***
	Perceived Knowledge Conservation Behaviors[bc]	0.009	0.166	0.868	0.039	0.732	0.465	0.032	0.716	0.474	--	--	--
	Identification of Conservation Building Features[b]	- 0.037	- 0.764	0.445	0.001	0.014	0.989	0.028	0.638	0.524	- 0.092	- 1.799	0.073
	Identification of Conservation Behaviors[b]	0.051	0.689	0.492	0.020	0.414	0.679	0.009	0.107	0.914	0.068	1.182	0.238
Building Characteristics	Features that Prime ERB Overall	0.585	2.647	0.009 **	0.571	2.597	0.010 *	0.004	0.012	0.990	- 0.294	- 1.739	0.083
	Features that Permit Behavior[d]	0.155	0.387	0.699	- 0.081	- 0.734	0.464	- 0.723	- 1.941	0.053	--	--	--
	Features that Invite Behavior[d]	0.510	0.666	0.506	0.081	1.661	0.098	0.383	2.760	0.006 **	- 0.595	- 1.608	0.109

**p* <.05, ***p* <.01, ****p* <.001

[a] Reference level -- Variable not included in model

[b] Relevant to behavior category (e.g., Knowledge of *Energy* Conservation Building Features or *Energy* Conservation Behaviors)

[c] For Travel Behavior, Perceived Knowledge is combined into one variable: Perceived Knowledge of Travel Alternatives

[d] Building features are relevant to behavior category (e.g., Features that Permit *Energy* Conservation Behaviors or Features that Invite *Energy* Conservation Behaviors)

RQ2: Building Characteristics and Behavior Change Over Time

Analyses of occupant ERBs over time by residence hall in Chapter III revealed distinct trends among the residence halls. In general, occupant behavior in each of the behavior categories improved over time while only one residence hall demonstrated a clear departure from this pattern. Students in building A.2, a green residence hall in its first year of housing students, reported lower ERBs in all four behavior categories over time (See Table IV-4).

Table IV-4. Change in Mean ERBs from T1 to T2

Residence Hall	ENERGY	WATER	MATERIALS	TRAVEL
A.1	0.038	0.179	0.298	0.044
A.2	-0.459	-0.424	-0.142	-0.062
A.3	0.162	0.381	-0.053	-0.106
B.1	0.102	0.109	0.059	-0.083
B.2	0.390	0.228	0.350	0.180
B.3	0.117	0.404	0.164	0.087

Note: Residence halls in which students reported poorer conservation behavior over time are indicated in the grey boxes for each behavior category. (See Chapter III for a full summary of these results.)

In consideration of these data alongside the building characteristics scored by applying the PSBE model to the residence halls, one would expect residence halls in which there was a decline in behavior over time to perform lower on the significant predictor variable for that behavior category. For the purpose of this analysis, the mean value of a single building characteristic was calculated across all residence halls. Residence halls scoring above the average for a particular building characteristic are highlighted in green in Table IV-5. Residence halls falling below the average are not highlighted. Residence halls where behavior declined over time and the mean building characteristic score fell below average are indicated with red text.

Table IV-5. Mean Building Characteristic Scores Across Residence Halls

Residence Hall	ENERGY		WATER		MATERIALS		TRAVEL		PRIME
	PERMIT	INVITE	PERMIT	INVITE	PERMIT	INVITE	PERMIT	INVITE	
A.1	1.67	0.00	3.00	2.00	1.08	0.42	0.25	0.17	1.42
A.2	2.17	0.25	2.00	1.00	1.42	0.17	0.25	0.25	1.42
A.3	2.36	0.36	2.00	3.00	1.09	0.46	0.27	0.09	1.18
B.1	1.73	0.09	2.00	0.00	1.64	1.46	0.27	0.09	1.82
B.2	1.91	0.00	3.00	3.00	1.55	1.55	0.27	0.36	1.73
B.3	1.67	0.00	2.00	0.00	1.50	1.50	0.25	0.08	1.42
Avg. Score Across Halls:	1.92	0.18	2.33	1.50	1.38	0.92	0.26	0.17	1.50

[green box] > Average score across halls (Scale 0-3)

Text in Red indicates behavior declined over time and significant predictor building characteristic falls below average

Note: Travel Permit was not actually included in the final statistical analysis because the raw scores of the individual spaces within the residence halls were identical. Three residence halls did not have one of the types of spaces (e.g. a special events lounge or a computer room), thus although it appears that the average scores across the individual spaces within each hall were slightly different, the lack of true variability among these scores prevented this variable from explaining any difference in the outcome variable.

The results of the LMERs reveal that for the behavior categories in which there was a significant predictor building characteristic (Energy, Water, and Materials), a residence hall in which behavior declined over time also scored below average on the evaluation of the relevant building characteristic. As the *Prime* domain was significantly associated with improved conservation in the categories of Energy and Water behavior, it was hypothesized that the behavior of students residing in buildings scoring below average in this domain would decline over time. Building A.2 was the only residence hall in which students reported decreased conservation behaviors over time in both of these categories (see Figures III.1 and III.2, which have been reproduced below as Figure IV.5 for reference). As predicted, building A.2 scored below average in the *Prime* domain (A.2 M = 1.42). (See Table IV-5).

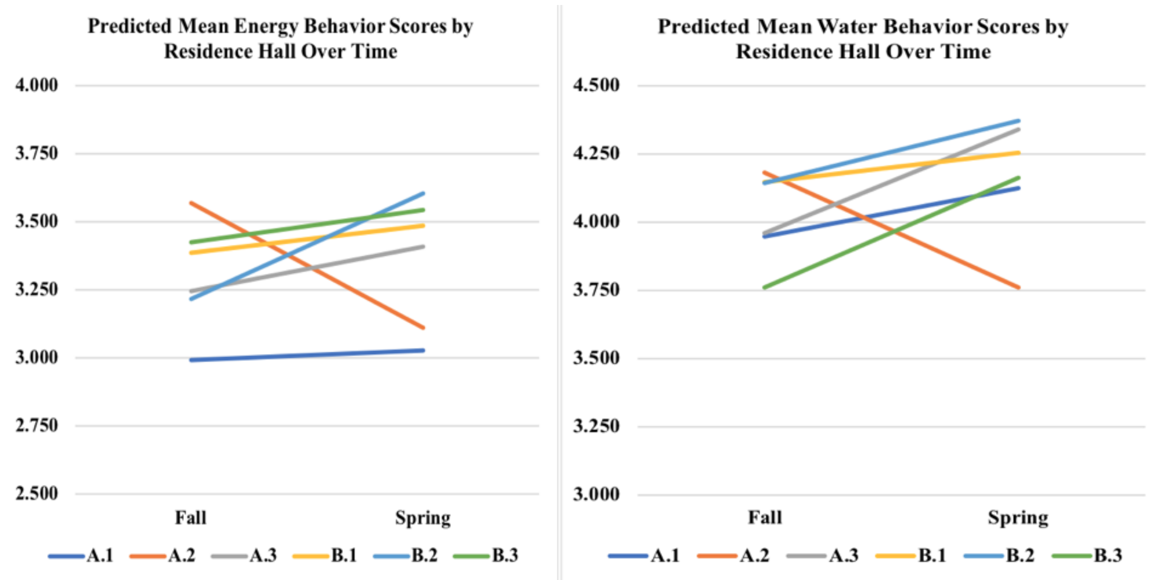

Figure IV.5. Energy and Water Behavior Scores by Residence Hall Over Time
Results from the linear mixed-effects regression models demonstrate that only students in building A.2 report declined conservation behavior over time in the categories of Energy and Water.

The *Invite* domain was significantly associated with improved Materials conservation behavior; thus it was hypothesized that any residence hall in which students reported declined Materials conservation behavior over time would also score below average on this building characteristic. Two residence halls declined over time in Materials conservation behavior and both also scored below average on the Materials_Invite building characteristic (A.2 M = 0.17; A.3 M = 0.46). As no building characteristics were significantly associated with changes in Travel Behavior, no conclusions can be drawn about the possible relevance of these building characteristics to the three residence halls that declined in Travel behavior over time.

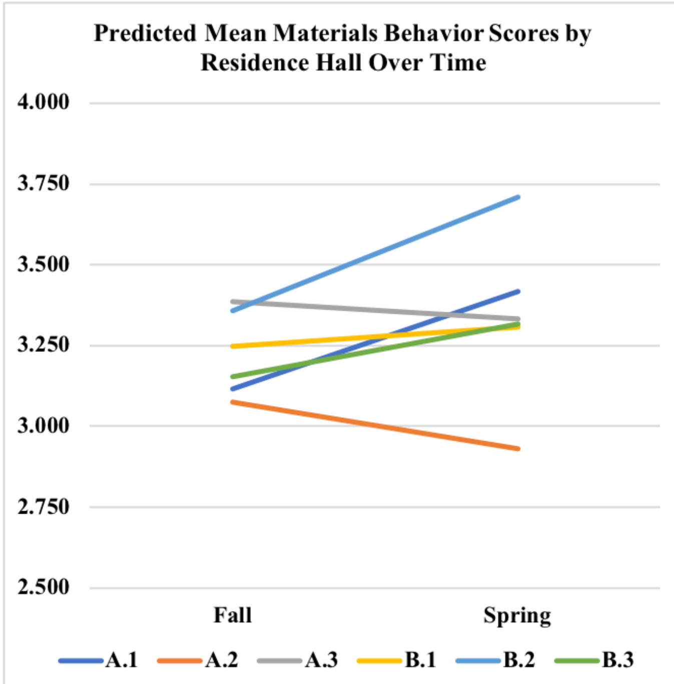

Figure IV.6. Materials Behavior Scores by Residence Hall Over Time
Results from the linear mixed-effects regression models demonstrate that students living in buildings A.2 and A.3 report declined conservation behavior over time in the category of Materials conservation behavior.

Discussion

This study has two purposes: 1) to apply the Positive Sustainable Built Environments model to the analysis of six university residence halls to explore the significance of the three domains (Prime, Permit, and Invite) for predicting occupant ERBs; and 2) to determine if the previously identified trends in behavior over time among the residence halls are consistent with the residence halls' scores in each of the PSBE domains.

Priming ERB

The *Prime* domain emerged as the most influential domain from the Positive Sustainable Built Environments model, significantly predicting improved ERBs in two out of four behavior categories at a fairly large magnitude (approximately 8% increase). There are two principal themes at the root of the *Prime* domain: attention restoration and sustainable ethos. The first concerns what Orr described as the "hidden curriculum" of green buildings (1997). This theme includes features that communicate something about the sustainable ethos of a place – the collective commitment to sustainability that is woven into the fabric and structure of a building. This may include features that remind occupants of their connection with the natural world, such as a mixture of natural materials or motifs incorporated into the finishes and furniture of a space. A sustainable ethos may also be cultivated in simple instances of communication from the environment to the occupant, the identifying of a sustainable feature, or the highlighting of how a particular building system avoids wasteful consumption of resources. In simply promoting awareness of these features, the environment may not specifically *permit* or *invite* occupants to take an action. But awareness of building features can contribute to the overall sense that "this is a sustainable place" and "this institution must value the environment."

One of the variables from the survey measured students' awareness of conservation building features by asking them to list up to three features of their residence hall that related to the different behavior categories. The results support the notion that even the awareness of one sustainable building feature, without noting anything of their interaction with the feature, is associated with improved ERB. In the LMERs presented above, students' identification of building features was coded on a 0-3 continuous scale, which showed no relationship with students' ERB. However, when recoded into a binary categorical variable indicating a student's identification of either zero (response of "I don't know") or at least one conservation building feature, students who could correctly identify at least one building feature related to the conservation of energy reported statistically significant higher Energy conservation behavior scores (M=4.10, SD=0.76) than students who could not identify an energy conservation building feature (M=3.96, SD=0.79); $F(1, 550) = 4.35$, $p = .038$. Similarly, students who could correctly identify at least one water conservation building feature reported statistically significant higher Water conservation behavior scores (M=4.32, SD=0.69) compared to students who indicated "I don't know" or "none" (M=4.03, SD=.79); $F(1, 502)=15.61$, $p = .000$. Lastly, students who identified at least one correct materials conservation building feature also reported higher Materials conservation behavior (M=4.81, SD=0.73) versus students who could not provide a materials conservation feature (M=4.52, SD=0.78); $F(1, 467) = 16.48$, $p = .000$. Thus even when features may not relate specifically to occupant behavior, occupant <u>awareness</u> of these features is associated with greater ERBs in the relevant behavior categories.

The path to cultivating this awareness of conservation features in the building is somewhat uncertain. One possible path includes intentional instruction about the sustainability features of a building to new occupants. It is unknown whether the students received any sort of formal (via a tour) or informal (via an informational pamphlet) instruction about the conservation building features upon moving into their residence hall. However, no such materials were visible during the two visits at each site. Alternately, students may have become aware of the features through their daily interactions with the building. In this case, the extent to which conservation features are able to "speak for themselves" is encouraging and worthy of further study. Future research should ascertain how students develop awareness of sustainable building features.

The second theme of the *Prime* domain concerns features within the built environment that may foster mental vitality through attention restoration. While attention restoration has been previously connected to stewardship behavior (Hartig, Kaiser, Strumse, et al., 2007; S. Kaplan & Berman, 2010; Tennessen & Cimprich, 1995), most research has addressed the intentional pursuit of attention restoration, often advocating for various degrees of contact with nature, including views of nature through a window (R. Kaplan, 2001) to physical activity in nature (Berman, Jonides, & Kaplan, 2008; De Young, 2010; Pretty, Peacock, Sellens, & Griffin, 2005). Largely, the onus to mentally restore is placed on the individual. To reap the benefits of cognitive clarity, one must choose to take a break, rest one's mind, to seek out a natural view or walking path. This study is unique in that the buildings included are not being formally used for environmental education, and the participants in this study were not encouraged to participate in attention restoration activities within or around their residence halls. Thus, the features included in the *Prime* category are thought to support ERBs through the *unintentional* restoration of mental vitality. The most commonly identified features in this category include windows to the outdoors with varying degrees of visible nature; places for reflection including interesting outdoor walking paths (see Figure IV.7); indoor vegetation (see Figure IV.8); and natural light that produces fascinating patterns with changing shadows throughout the day (see Figure IV.9).

Figure IV.7. Outdoor Walking Paths
Walking paths outside three residence halls at University A give residents and other pedestrians opportunities for quiet reflection and contact with nature. [Photos by author.]

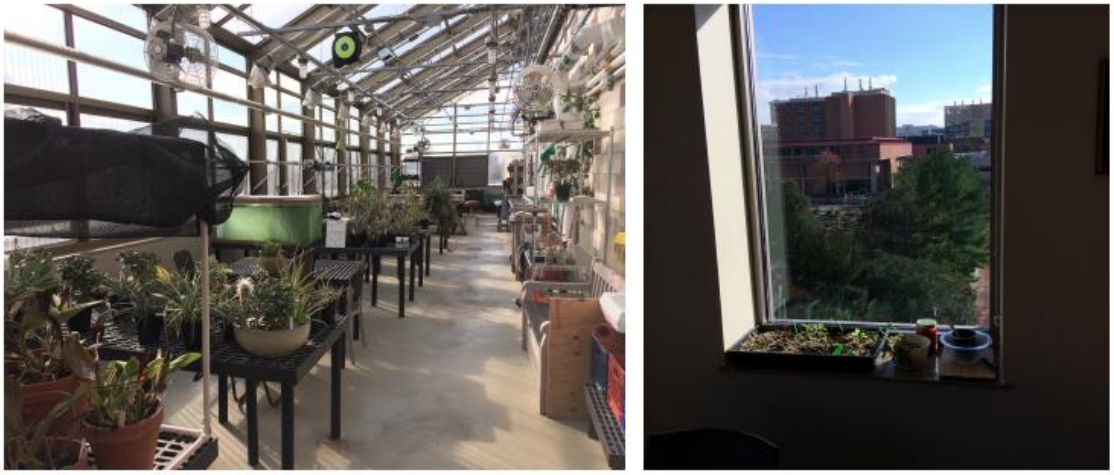

Figure IV.8. Indoor Vegetation
An indoor greenhouse and potted herbs inside residence hall A.2 give occupants regular opportunities to interact with and care for nature. [Photos by author.]

Figure IV.9. Natural Light and Shadow Patterns
The changing patterns of shadows throughout the day alters the experience of space, creating moments of fascination and connection to the outside world. [Photos by author.]

The impact of the *Prime* domain on undergraduate's ERBs is particularly interesting as this is a population that is often reported as chronically attention fatigued (Felsten, 2008) and, like most other adults, are not particularly adept at gauging the restorative potential of a setting or activity. People are known to underestimate the potential benefits of being in nature (Nisbet & Zelenski, 2011) and often fail to make use of nearby natural sites. Additionally, adults (including undergraduates) may often opt for television/media use or attending lively social gatherings because they perceive these activities will be effective means of mental restoration. While potentially stress-reducing, these activities, full of “hard fascination,” are rarely conducive to the mental restoration that arise from soft fascination and reflection (Basu, Duvall, & Kaplan, 2018). The latter settings (e.g., walking through a park, listening to the sound of a nearby stream, or watching a sunset) afford opportunities for mental restoration known to be more compatible with identifying and choosing environmentally responsible behaviors (Jacob, Jovic, & Brinkerhoff, 2009).

Permitting ERB

The *Permit* domain of the PSBE model yielded no clear or consistent relationship to occupant ERBs in any of the behavior categories. It had been hypothesized that within the context of increasing building automation, the loss of opportunities to participate in conservation behaviors, even as simple as turning off the lights when leaving a room or manually turning off the faucet while brushing teeth, would slowly erode previously existing patterns of ERBs. Conversely, environments that permitted occupants to actively engage with these behaviors were hypothesized to support the development of individual ERBs into long-term habits.

This study is one of very few that looks specifically at building features in support of occupant ERBs without a formal environmental curriculum or behavior change intervention. Moreover, this study is the first effort to operationalize the Positive Sustainable Built Environments model to explain the impact of building design on occupant ERBs. The present scoring procedure for the *Permit* and *Invite* domains awarded one full point for every feature identified in the selected representative images. However, the scoring scale, ranging from 0-3, may have been too coarse to distinguish between meaningful differences in some relevant building features. Building A.2 was the only building where the overhead lights in several spaces were operated by an automatic sensor with a manual override. Because these features had the manual override option, they were evaluated as equivalent to a conventional manual switch. However, because the analysis was based solely on visual evaluation of the photographs and not actual behavior, it is unknown if students regularly used the manual override to the same extent students might use a conventional manual switch. Although the automatic sensors afforded a manual override, it is possible students deferred to the automated feature rather than choosing to manually turn the lights off if they were vacating the room or felt the room had enough natural light. Future studies should consider revising the scale and potentially including a behavior observation component in the data collection.

Additionally, it is possible there was some confusion around who or what is the agent of behavior in buildings with greater automation. Watson et al. discuss the prevalence of features such as lights and water faucets that function on sensors in newer residence halls and suggest students may perceive "it is the building itself that turns off the lights and water, rather than the students actively doing this themselves" (2015, p. 321). The Likert scale for student ERBs included an option for students to choose "Not Applicable" if they did not have the capability to perform a particular ERB. However, it is unknown how many students without the capability to manually turn off the lights or adjust the thermostat did not make use of the N/A option when features in their hall impeded their behavior; opting instead to indicate that they did not perform the behavior would have resulted in negatively skewed behavior scores. The issue of agency as it relates to how building features *permit* certain behaviors is one that complicates interpretation of the results and is something to consider in future iterations of the behavior survey.

Inviting ERB

The *Invite* domain of the PSBE model significantly predicted increased Materials conservation behavior through easily observable instances where features within the environment were used to inform, instruct, and initiate behavior. Several residence halls across both university campuses offered drinking fountains with water bottle filler spouts. In a few of the halls, this feature, which allows students to make use of reusable water bottles, also included a behavior intervention component in the form of feedback about the number of plastic bottles deterred from landfills (see Figure IV.10).

Figure IV.10. A Tale of Three Drinking Fountains
Compared to the conventional drinking fountain on the left, the fixtures in the middle and on the right afford users easy access to filling a reusable water bottle (i.e., they Permit this conservation behavior). However, only the fixture on the right Invites conservation behavior, by providing users with feedback about their behavior (e.g., how many plastic bottles saved from landfills) and establishes a social norm that many others are participating. [Photo on left: https://www.pexels.com/photo/drinking-fountain-school-water-159756/; Center and Right Photos by author.]

All of the residence halls analyzed in this study provide residents procedural guidance about responsible recycling and waste disposal. Posters are always used in the trash rooms, and sometimes throughout other common spaces, to educate residents on the types of materials that can be recycled, the necessary procedures for recycling larger items, and identifying products that are compostable (where applicable). See Figure IV.11 for examples of recycling and composting instructional materials.

Figure IV.11. Sort This, Not That…
A variety of signage is used throughout residence halls to provide occupants procedural guidance regarding recycling, trash, and composting procedures. Instructional information is often paired with a declaration of social norms (e.g., "We Conserve") or the subtle communication of the consequences of not performing the desired conservation behavior (e.g., labeling the trash bin "Landfill"). These are multiple ways that elements in the built environment are used to Invite conservation behavior. [Photos by author.]

The most prevalent examples of the *Invite* domain appeared in all three residence halls on Campus B, which used a multiple-sort recycling system such that next to every waste bin were two options for disposing of recyclables: paper products, and aluminum and plastic. The increased opportunities to sort waste into multiple bins (resulting in extra points for the *Permit* domain) also yielded increased opportunities for repeated exposure to material conservation messaging. Campus B used a consistent messaging campaign consisting of waste bin decals utilizing a variety of behavioral intervention strategies. Every observed waste bin was covered with a decal labeled “LANDFILL” with an accompanying image of a landfill on the bin. This seemingly small message contributes to students’ overall understanding of the consequences of creating and disposing of garbage. This “awareness of consequences” is a psychological construct included in several behavior change models (Hines et al., 1987; Schwartz, 1977b; Stern, 2000). Additionally, each of the recycling receptacles are also covered in decals boasting, “WE CONSERVE,” thus supporting a social norm (Ajzen, 1991; Ajzen & Fishbein, 1980; Schwartz, 1977b) of conservation at the university. Because these bins are placed in almost every public room of the residence halls, and not just within a centrally located “trash room,” students receive increased exposure to these messages, thus normalizing material conservation behavior.

Building Characteristics and Behavior Change Over Time

The building characteristics may explain the change in environmental behavior over time in the residence halls that experienced declines in behavior. However, some residence halls with below average building characteristic scores still improved their ERBs over time, which suggests that there are likely other supporting factors that influence the effect of the building characteristics on occupant ERBs. This study did not explore any interaction effects among the domains of the PSBE model and this could be a fruitful line of inquiry for future research. For example, with respect to Water conservation behavior, buildings A.1 and A.3 scored below average in the *Prime* domain (the significant predictor variable for Water behavior), yet their Water conservation behavior increased over time while the students in building A.2 declined. A possible explanation for this finding is that the buildings surpass building A.2 in the Water_Permit (A.1) and Water_Invite scores (A.1 and A.3). While there was no clear relationship between these variables alone and students' Water conservation behaviors, it is possible they play an intermediary role between the *Prime* domain and Water behavior.

Regarding the decline of ERBs in building A.2 in every behavior category over time, there is possibly some effect outside of the building characteristics measured that impedes students' behavior. The overall decline in behavior observed in building A.2 might be attributed to A.2 being a new building. Although all participants in the study, regardless of residence hall, were first-time residents in their halls, it is possible that in more established residence halls, first-year residents benefitted from the institutional and social knowledge of returning residents. Older returning students hold previous experience that allows them to easily model environmentally responsible behaviors for new residents. Where a new student may not feel confident adjusting the thermostat in a common space, seeing a returning resident perform the action both conveys that it is a socially acceptable behavior and communicates useful procedural knowledge. Although Resident Advisors (or RAs, older students who have lived in other residence halls previously) may effectively model these behaviors, the small number of RAs relative to all new residents in the hall decrease the likelihood that RAs serve as highly visible examples of conservation behaviors. Residents in A.2 did not have the benefit of a large group of elder peers in their hall. As a new residence hall, every student's experience was that of a novice, and this may have negatively impacted the reported ERBs in this hall.

Limitations

Some of the limitations of this study relate to study design and the methodology used. Comparative case studies are challenging due to the number of extraneous variables that may impact the focus of the study. In choosing case study sites, the researcher attempted to control for geographic region, climate, university size, university culture of sustainability, and similarity of residence halls. Environmentally responsible behavior was measured via two online surveys that relied on participant self-report data about individual behavior. It is possible the data might have been skewed due to social desirability bias, though anonymous online surveys typically reduce this threat. Additionally, response rate is a challenge with online surveys, particularly with busy undergraduate students. Participation was incentivized by inviting students to submit an email address for entry into a drawing for one of four $25 gift cards per residence hall and several reminder emails were distributed during each of the three-week data collection periods.

Additional limitations of this study include the choice of building typology. Residence halls provided an ideal setting for a quasi-experimental and case study design because residents could be surveyed upon first moving into their residence halls and later in the school year. However, residence halls do not provide a great variety of unique or avant garde design features. As the *Prime* domain was found to be a significant building characteristic associated with ERB, it is possible that this effect might be enhanced in buildings with higher impact design. Staying within college campuses, an alternate building typology might include student centers that are increasingly visually dynamic, as the social hubs on campus for students, alumni, and donors alike.

This study involved an exploratory approach to operationalize the Positive Sustainable Built Environments theoretical model proposed in Chapter II. Scoring was conducted based on one researcher's assessment of two-dimensional photographs. It is possible there are relevant building features that were missed during the photo documentation phase. Future research could revise the evaluation procedure to include an in-person assessment of the building. Additionally, plans to involve a co-scorer of the building features did not materialize. A co-scorer would have improved the robustness of the scoring and allowed the researcher to defend against challenges asserting bias in the scoring. This is an issue that will be addressed before submitting this paper for publication. Future research could combine researcher scoring of building features with occupant assessments using focus groups or individual residents who score their buildings on these measures.

Implications

This research has important implications for the design of residence halls and other buildings to support ERBs among building occupants:

1. Previous research on the effects of residing within a green versus a conventional residence hall on occupants' ERBs have yielded mixed results. This research adds to this complicated narrative – green buildings do not seem to unilaterally support improved environmental behaviors. Encouragingly, this study suggests that environmentally responsible behaviors may be cultivated in both green and non-green buildings, depending on the individual features within and around the building. Particularly for Material conservation behavior, initiatives that invite occupants to use and dispose of resources responsibly, are effective means of supporting desirable behavior. These include feedback in the environment about waste reduction, attaching waste reduction behaviors to valued social identities through explicit communication of social norms, and features that communicate undesirable consequences of wasteful behavior, among others. Features that provide opportunities for attentional restoration (e.g., windows, views to nature, daylighting and shadow patterns), and cultivate an appreciation of the sustainable ethos of the environment (e.g., mixture of natural materials and motifs, communication of the sustainable features in a building) contribute to priming occupants to participate in ERBs.

2. Lastly, this study addresses a somewhat neglected area in the psychology of environmental stewardship, which is the role of the situational context to informally support environmentally responsible behavior. Rarely do researchers approach behavior change outside of a formalized behavior change intervention. However, the potential to impact a wider population is possible if research was focused on creating conditions in which multiple environmentally responsible behaviors may flourish. This study advances knowledge of these supportive conditions, which include features in the building that seem to support the effortless or unintentional restoration of attentional capacity, features that make occupants aware of the sustainable features within buildings, and features that invite specific conservation behaviors by appealing to multiple value orientations and motivations.

Conclusion

Green buildings have the potential to support ecologically conscious behavior, though green buildings do not exclusively exercise this influence. Previous research has established that environmentally responsible behavior is shaped by many factors, including one's existing knowledge informed by previous experience, value orientations, behavioral motivations, and complex social dynamics that unfold in a variety of physical contexts. This study found that occupants' environmental actions may be influenced by a number of behavioral factors facilitated at the feature level in both green and conventional buildings. Future research is needed to further test the Positive Sustainable Built Environments model in residence halls as well as other building typologies. Additionally, future studies should consider the social aspects of behavior, particularly with respect to how spatial orientations of the built environment facilitate environmentally responsible behavior to be modeled for other occupants. The outcomes of this research support the Positive Sustainable Built Environments model as a foundation for organizing a conversation around the intersecting domains of agency and control over environmental conditions; applications of behavior change strategies in the built environment; and the ever-present role of cognitive clarity in human functioning. These all collide at a time when human responses within a complex and changing global climate are among the most important challenges we face.

CHAPTER V

Designing the Supportive Context: Implications for Environmental Behavior Change and the (Green) Built Environment

Industry responses to the challenges posed by a changing climate and the need to conserve resources have prompted technological innovations that reduce greenhouse gas emissions and are responsive to local ecological conditions. In particular, the green building industry seeks to minimize the environmental impacts of the construction process and the ongoing maintenance of the built environment. Green buildings have been praised for their energy and resource efficiency, design innovation, and benefits to building occupants (Benfield et al., 2015; Hua et al., 2014; Kelz et al., 2015; Lennon et al., 2017; Paul & Taylor, 2008; Thatcher & Milner, 2016).

As a counterbalance to the dominant narrative in the green building industry that frames the building occupant as a potential energy liability, a growing body of contemporary literature has begun to examine the interactions between green buildings and occupants' environmentally responsible behaviors. This is a fruitful pairing for scholars in environmental psychology as Americans currently spend the majority of their time indoors. Thus, the physical context of the built environment is ubiquitously present as a backdrop to innumerable daily decisions that potentially impact the natural environment. Currently it is unknown if and to what extent the built environment influences people to make more responsible environmental decisions.

Related research in this area has focused primarily on the formal relationships between green buildings and human behavior. Principally, research on green educational environments has examined the use of green buildings as teaching tools in partnership with a formal environmental education curriculum (Aulisio, 2013; L. B. Cole, 2015; L. B. Cole & Altenburger, 2017). Additionally, researchers from environmental and conservation psychology have implemented formal behavior change interventions in green (and non-green) buildings to further refine what is known about shifting human behavior toward more durable sustainable lifestyles (Abrahamse et al., 2007; Ham & Midden, 2006; Han & Hyun, 2017; Parece et al., 2013).

Parting ways with this previous research, the study presented here has focused on environmental behaviors emerging from the informal relationship between undergraduate students and their on-campus residence halls. In this case, the green buildings chosen for this study were not designed with pedagogical intent, nor did the researcher implement any behavior change strategies. This dissertation simply asked: How do buildings support or undermine the environmentally responsible behavior of building occupants in green and non-green buildings over time?

This chapter presents an overview of the Positive Sustainable Built Environments model (Chapter II) and a summary of the personal and contextual factors (Chapters III and IV) that contribute to occupant ERBs in undergraduate residence halls. The chapter will discuss the implications for practitioners seeking to design green buildings that support the growth of occupant ERBs, both within and beyond the green building context. The chapter will conclude with a discussion of future directions for research to further refine the Positive Sustainable Built Environments model.

Summary of Findings

Chapter II: The Positive Sustainable Built Environments Model

Chapter II of this dissertation presented the Positive Sustainable Built Environments model, building on the theoretical proposition by Corral-Verdugo and Frias-Armenta (2015) that positive built environments should not only provide immediate benefits to occupants[22] but they should also encourage occupant behaviors that sustain the environment into the future. The Positive Sustainable Built Environments model proposes three domains through which buildings may influence occupants' environmentally responsible behaviors (See Figure V.1).

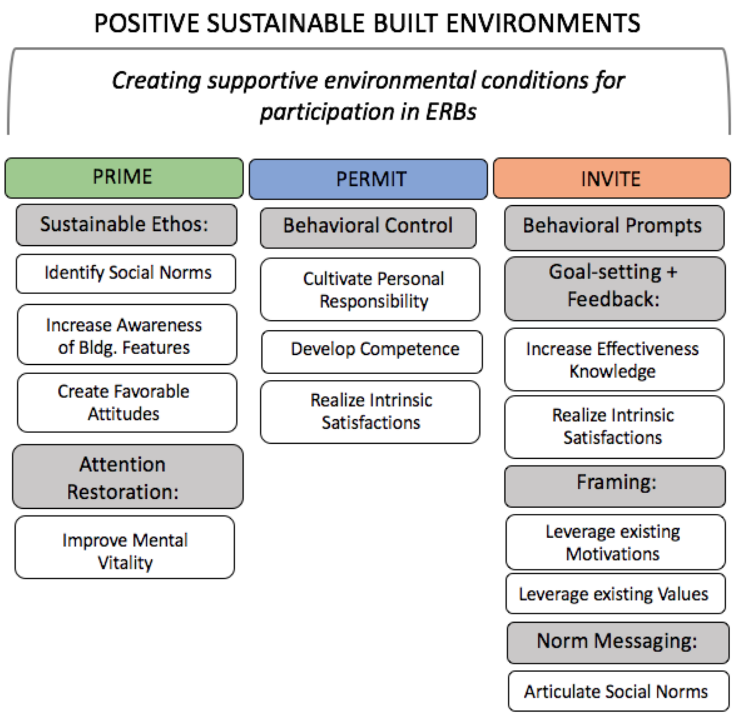

Figure V.1. The Positive Sustainable Built Environments model
The model is composed of 3 domains proposed to support ERBs in buildings: Prime, Permit, and Invite.

22 Benefits of inhabiting sustainable environments have been documented in detail, including positive indoor air quality, thermal comfort, satisfaction with daylighting, etc.

The first domain of the Positive Sustainable Built Environments model posits that buildings can *Prime* occupants to be more receptive to environmentally responsible behaviors. This domain emerges from the literature on effective functioning and attention capacity, namely that: 1) it is normal and expected for human cognitive functioning to fatigue over time (S. Kaplan & Berman, 2010), 2) there are behavioral consequences to this fatigue (De Young, 2010), and 3) there are environmental conditions that can restore this capacity (Rachel Kaplan & Kaplan, 1989c; Stephen Kaplan, 1995).

Cognitive fatigue produces a number of distinct and separate effects that impede a person's capability to participate in ERBs. Irritability, decreased capacity to think ahead, and the diminished likelihood to engage in helping behaviors can all result from mental, fatigue. Rest of one's attentional capacity is critical to attention restoration and an exemplar supportive environment for restoration is contact with nature (Berman et al., 2008; R. Kaplan, 2001). The inherently fascinating content of natural elements, sounds, colors, and textures prompt effortless observation and allow the recovery of one's cognitive capacity. Thus, features in the built environment that expose building occupants to nature can restore their attentional capacity, and therefore make it more likely that they will participate in environmentally responsible actions.

A second aspect of the *Prime* domain relates to the extent to which an environment communicates a cultural commitment to sustainability. In this dissertation, this characteristic is called *sustainable ethos*. Sustainable ethos may be communicated through a variety of interior and exterior building features. A mix of natural and responsibly sourced materials, "green-branding" such as the LEED® seal, and any environmental communication that seeks to educate building occupants about the sustainability of certain building features may all contribute to the collective *sustainable ethos* of a place.

The second domain, *Permit*, refers to the degree to which occupants are afforded the ability within the building to participate in behaviors that have an environmental impact. These include the capability to control the environmental conditions in buildings by adjusting thermostats, opening windows, turning on/off lights. Occupants may actively control the amount of water they consume by manually operating water faucets or selecting the appropriate designations for dual flush toilets. Additionally, occupants may be actively engaged in responsible waste disposal by sorting recycling into separate bins and disposing of compost.

The ability for building occupants to participate in controlling the conditions of their interior environments and the degree to which they consume resources inside buildings is significant for two central reasons. The first concerns the complicated relationship between human beings and automation. Recent research has found that automated systems intended to reduce energy and other resource consumption in the building are often undermined by occupant behaviors in reaction to the lack of perceived control over the environment (Murtagh et al., 2015). Secondly, habitual patterns of behavior performed in one context can potentially spill over to other contexts. A building that trains occupants not to engage with building systems also trains occupants not to think about how to actively engage in conservation behaviors within the building (e.g., if turning off the lights becomes unnecessary in one context because of automation, turning off the lights may fade from practice in other contexts).

Thirdly, as positive sustainable built environments are expected to support occupants in sustaining the environment into the future, the final domain of the model is entitled *Invite*, which encapsulates the many ways behavior may be prompted, nudged, or boosted within the built environment. Strategies from traditional environmental behavior change interventions may be implemented throughout the built environment to promote ERBs. For instance, prompts are often used to remind occupants to turn off the lights or water when not in use. Signage communicates procedural information to instruct occupants how to operate a dual flush toilet. Feedback about energy consumption is publicly displayed on flat screens in building lobbies. Written communication is used frequently to frame particular behaviors within a recognizable value orientation (like care for the environment).

As the empirical literature in conservation psychology has revealed, the most effective behavior change interventions are ones that employ a great quantity and variety of strategies that appeal to the particular combination of previous experiences, values, and motivations of each individual (Abrahamse et al., 2005, 2007). The same concept of multiple interventions was hypothesized as also applying to features in green buildings when articulating the *Invite* domain.

Chapter III: Personal and Contextual Dimensions of ERBs in Residence Halls

Chapter III uncovered the existing personal and broad-scale contextual dimensions that contribute to undergraduate ERBs in on-campus residence halls. From a behavioral intervention perspective, numerous studies employ a variety of intervention strategies to induce changes in behavior (Emeakaroha, Ang, Yan, & Hopthrow, 2014; Karp, McCauley, & Byrne, 2016; Parece et al., 2013; Petersen et al., 2007; Wisecup et al., 2017). However, rarely do researchers acknowledge the potential role of pre-existing values and motivations of undergraduate students in these studies. As the literature review in Chapter III shows, it is often incorrectly assumed that students living in residence halls would not be motivated to participate in ERBs because they bear no financial responsibility for their energy and resource consumption (Bekker et al., 2010).

The results reported in Chapter III reveal that undergraduate students are actually quite motivated by environmental concern, and this motivation positively impacted both their Water conservation behavior and Material disposal behavior. Further, the factor analysis of the motivation items included in the online survey instrument revealed that while the Environmental Concern motive was highly coherent (alpha = 0.94), it consisted of a wide variety of behaviors. Not only did students' Environmental Concern include items that would traditionally be associated with nature (e.g., restoring natural areas, caring for the land, protecting natural places from disappearing), but for these undergraduate students, Environmental Concern also included a social orientation (e.g., making the environment better for others, helping bring order to the world), as well as an association with personal benefits (e.g., learning about my surroundings, a chance to be outdoors). Students motivated by opportunities to engage with technology also reported higher conservation behaviors in the categories of Energy and Material conservation. Consistent with previous studies, Egoistic values were frequently associated with significantly poorer performance of ERBs and students identifying as male were also significantly more likely to report poorer conservation behaviors than their female peers[23].

Chapter III also examined the broad-scale contextual factor of living in a green versus a conventional residence hall for an effect on occupant ERBs over time. While no consistent significant relationship emerged between building greenness and occupant ERBs, further examination of the individual residence halls included in the study revealed steady trends among most of the residence halls – multiple environmentally responsible behaviors improved over time, regardless of whether students lived in a green or conventional building.

However, for one residence hall (A.2), behavior in each of the categories (i.e., energy, water, materials, travel) consistently declined over time. This unexpected discrepancy is possibly attributable to chance – it is possible building A.2 was simply an unexplainable outlier.

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23 Males also reported significantly higher Egoistic values than females, possibly explaining this depressed trend in ERBs.

Alternately, building A.2 was also in its first year of occupation, and therefore all students in the building were new residents, thus having no veteran residents to serve as role-models of learned building-specific ERBs. However, it is also possible that particular characteristics within all of the residence halls, independent of the building being green or conventional, were the cause of the significant differences among occupants' ERBs over time. This possibility was explored in the next chapter of the dissertation.

Chapter IV: Do buildings Permit, Prime, and Invite ERBs?

Chapter IV sought to characterize and quantify the features of green and conventional residence halls that either support or undermine occupants' environmentally responsible behaviors by applying the Positive Sustainable Built Environments model to an analysis of building features.

Overall, the empirical findings support two of the three major components of the Positive Sustainable Built Environments model. The results revealed that students living in environments scoring higher in the *Prime* domain reported significantly better Energy and Water conservation behaviors. Additionally, environments in which features specifically appealed to occupant behavior (i.e., scoring higher in the *Invite* domain) were found to be supportive of Materials conservation behavior. The results of this study revealed no clear relationship between environmental features that *Permit* greater occupant control (versus automation) and the performance of ERBs. Conventional wisdom in the building industry favors automation technology (M. Becker & Knoll, 2014) because it eliminates threats to energy efficiency caused by occupant behavior that is perceived as negligent, wasteful, or ill-informed. However it is also known that occupant satisfaction with highly automated conditions is lower and can result in negative assessments of “green” environments and increased resource consumption[24] (Murtagh et al., 2015).

Despite the weakness of the Permit domain, the empirical findings reported here provide enough support to justify further development and design use of this model. The implications of these findings are significant and relevant for designers tasked with responding to the global necessity for more sustainable building practices and maintenance. *Sustainable design* need not only pertain to the efficiency of building systems and responsible use of materials; a truly sustainable design is one that also supports users in more environmentally responsible behaviors.

Design Implications: Creating a Supportive Context for ERBs

Environmentally responsible behavior emerges at the nexus of people and physical settings. The interactions are complex, having temporal, social, and physical scope. Individuals bring an array of previous experiences, values, motivations, and intentions to the built environments they inhabit. A specific built environment itself is the result of design decisions in the past with perhaps more recent modifications, and are thus characterized by different, perhaps unique, physical attributes. These factors might be characterized as “past driven” causes of the ERBs that are carried out in the present setting. But added to this are factors that emerge in the present moment from interactions in the situational contexts that have social and psychological

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24 Increased resource consumption may result from the phenomenon known as Jevon’s Paradox, where the perception of efficiency leads to a false sense that one can afford to consume more of a particular resource. Alternately, occupants in highly automated buildings may increase their resource consumption out of psychological reactance, as either a deliberate or unconscious means to undermine a setting they find unsatisfactory, or in other off-site settings.

features. Furthermore, people interact with the future as they operationalize their goals and goal-oriented aspects of their sustainability ethos, in the spaces in which they interact and inhabit.

Design for ERBs can be based on these several factors: past driven, present interacting, and future emerging. The practical applications emerging out of this research address design broadly, discussing guidelines for creating supportive environments at the informational, attribute, and architectural scales.

Design with the User in Mind: Extending Behavioral Invitations that Fit

Overwhelmingly it seems as though environmental behavior interventions in residence halls have been designed with a focus only on a particular outcome–a behavior–without acknowledging the pre-existing characteristics and experiences of the individuals performing the behavior. This study revealed a range of salient values and motivations held by undergraduates that support (and impede) students' ERBs. Supportive contexts for ERBs will likely appeal to the full range of values and motivations of building occupants.

Researchers Whitley et al. (2018) suggest tailoring interventions and environmental messaging in undergraduate residence halls to students' pre-existing values and goals, as revealed by their responses to a values assessment. This could be practical at the informational level in residence halls (e.g., adapting signage and communications to students accordingly). However, it is likely not financially nor practically feasible to tailor specific attributes and the broader architectural environment of the residence hall to individual, and changing, cohorts of students. Undergraduate students are a transient population. Though likely similar in many capacities due to their age group and embeddedness within the social culture of the same university, each academic year ushers in a new group of students. Furthermore, each cohort itself goes through significant change as a result of their college experiences. Students likely leave the residence halls a different individual from the one that entered a year or two earlier. As a result, the implications for designing supportive environments for this population include the pursuit of two goals: 1) Adaptability, and 2) Variability.

Design for Adaptability

Adaptability accommodates changing needs over time. Design for adaptability might include the provisioning of space that can be used for multiple purposes as programmatic needs shift to accommodate new and evolving sustainability initiatives. One of the residence halls included in this study (B.2) included a few spaces to be used for existing and evolving programmatic needs: a bicycle repair shop and a maker-space where students deposited scrap materials that could be repurposed by other students (see Figure V.2). Without the provision of these spaces, these functions may have slowly emerged in other locations; however, their presence in the residence hall afforded residents the opportunity to immediately participate in activities that provided knowledge and skill acquisition in support of ERBs. Simultaneously, the provision of these spaces communicated something about the ethos of the building and the social network developing inside it: we care about the environment.

Figure V.2. Bike Repair and Spare Materials Room
Adaptable space allows for changing programmatic needs in support of sustainability initiatives. [Photos by author.]

Design for Variability

Research on the broader adult population suggests that human behavior of all kinds is multiply determined (De Young, 2000). The same is true of environmental behaviors in undergraduate students. Previous studies have suggested that undergraduate on-campus residents would not likely be motivated to conserve energy and resources because they bear no financial responsibility. In contrast, the undergraduate students in the current study were motivated by both biospheric values and environmental concern. Informational features designed to *Invite* students to engage in ERBs were compatible with these characteristics; most signage encouraging a particular ERB appealed to an environmental-ethic. The repeated use of environmental slogans and branding that connected students' conservation behavior to valued social norms were effective means of behavioral coaxing that supported improved materials conservation behavior (refer to Table IV-3). However, other value orientations are also salient for undergraduate students and if leveraged appropriately, could support students in adopting additional environmentally responsible behaviors. Design for variability involves embracing a diversity of values in order to support ERBs in the broadest section of the population possible.

A principle often cited in universal design is to accommodate 95% of the population[25], thus anticipating anthropometric diversity and designing spaces that are useable by the largest reasonable segment of the population achievable (Openshaw & Taylor, 2006). Similarly, the design of buildings and environmental information features should accommodate the psychological diversity underlying environmentally responsible behavior. While the students in this study were motivated by environmental concern, their scope of concern for the environment encompassed more than an immediate care for nature. Students also consider the social impacts of environmental issues along with their own access to spend time outdoors as part of their concern for the environment. Informational features intended to promote ERBs could successfully leverage these other facets of Environmental Concern.

In the present study, the data showed that male students reported significantly lower ERBs than females in almost every behavior category. Further, males also reported higher levels of Egoistic values than females, and this particular value was consistently significantly associated with declined ERB performance. Thus, a significant proportion of the sample population is not being supported adequately. Rather than assume that young male students are incapable of adopting environmentally responsible lifestyles, it would be more accurate to suggest that there is a lack of behavioral fit between college-age males and the residence halls included in this study. Rather than seek to change the values of male undergraduates, the

25 This size range includes the 5th percentile female on the small end of the range to the 95th percentile male at the large end. 95% of the population are located between these two extremes.

environment might be altered to better appeal to the existing inclinations of male students. At an informational level, environmental communication could easily be diversified and framed to a greater variety of value orientations throughout the building (e.g., in this case, harnessing the Egoistic value orientation and appealing to the benefits to oneself of engaging in ERBs).

Designers seeking to be mindful of the variety of values and motivations the ultimate users might bring to their spaces have the responsibility to incorporate diversity into their designs. Designers may benefit from seeking out wisdom through partnerships with other entities at the university who are already collecting data on the environmental perspectives and behaviors of undergraduates and other populations on campus (e.g., researchers at the University of Michigan conduct an annual survey of sustainability culture on campus). Additionally, more research is needed to develop a broader picture of the existing values and motivations underlying ERBs in undergraduate students, without the intention of changing their behavior. Translating this research into digestible content for practitioners will be the responsibility of scholars working at the intersection of research and design.

Designing Environments to Prime Behavior

Environments assessed to *Prime* behavior through the presence of restorative elements and features that alluded to the sustainability of the building[26] were significantly related to improved Energy and Water conservation behaviors. While extensive research has linked attention restoration, particularly through contact with nature, to the cultivation of ERBs, this study suggests something slightly different. The empirical findings suggest that even without

26 Collectively, the elements under the *Prime* domain include: views to nature, natural light through windows, shadow patterns, multi-sensory features, spaces for reflection, natural materials, mix of materials, indoor vegetation, and posted educational signage about the green features of the building.

instruction to prompt awareness of their environs or to seek out opportunities to restore, students with these amenities in their buildings nonetheless reported improved ERBs. This is consistent with the notion that they informally experienced attention restoration just by inhabiting a building with restorative elements. If supported by future research, this finding has significant relevance to the design of environments for the promotion of ERBs.

The other theoretical component of the *Prime* domain addresses how the building conveys a *sustainable ethos*, both overtly through the provision of information and tacitly through the choice of materials and features designed into the space. In this study, students who were able to name at least one correct conservation feature of their residence halls reported significantly better ERBs in the categories of Energy, Water, and Materials behavior. Even if the identified building feature was unrelated to behavior, it seems that just being aware that their environment was "green" prompted ERBs. The residence halls included in this study have many green features that are underutilized from the perspective of communicating sustainability to occupants. Tasteful signage at the location of the visible feature or informational pamphlets describing the green features of the building could easily be adopted to enhance the sustainable ethos of the building, communicating to occupants that they, "are in a building that values the environment."

Bearing in mind these results, designers should be cautioned not to seek to maximize the number of informational features in the environment. Too much information, or information lacking clear organization, can be perceptually and cognitively taxing, resulting in the inability to adequately process new sources of input. Empirical studies employing the Preference Framework (R. Kaplan & Kaplan, 1989b) as a means of understanding human beings' natural inclination toward a balance of complexity and coherence would be informative in creating guidelines for designers about an effective balance of information and free exploration within a space.

In addition, designers may also want to consider the degree to which the spatial organization of a building permits residents' optimal awareness of sustainable features. In the residence halls included in this study, many of these features in the building were concentrated in the spaces with the most public-impact: lobbies, special events lounges, or conference rooms. Yet, building residents are typically quite transient in these spaces, likely spending most of their time in the semi-public/semi-private and private spaces of study lounges and bedrooms.

While not economically feasible to incorporate higher end materials in every resident room, space plans can be arranged to maximize students' visual access to these "Priming features." For instance in Residence Hall B.2, a greenhouse is located on the 4th floor of a 4-story residence hall. While only students who are specifically members of the greenhouse program have access to this space, locating this asset in a more communally visible location could be beneficial for all students by sparking curiosity and conversations around the value of the greenhouse. Similarly, hall B.3 made use of this principle by opening the upper residential corridors to views of the main lobby, which was anchored by a stone and wood-façade fireplace and floor-to-ceiling windows overlooking a lake (see Figure V.3). Thus, residents were able to benefit from these views long-after their brief passage through the lobby. The spatial location of features in residence hall merits future research. Designers should consider not just the spaces that yield the highest traffic, but potentially, the highest dwelling time to boost students' exposure to these features.

Figure V.3. View from Corridor to Lobby Interior
Open residential corridors permit views to nature through floor-to-ceiling windows overlooking a walking path along the lake. [Photos by author.]

Directions for Future Research

Future research developing out of this dissertation will focus on refining the Positive Sustainable Built Environments model through additional empirical studies and theoretical work. Given the magnitude of impact the *Prime* domain had on Energy and Water conservation behaviors in undergraduate residence halls, this is a particularly worthy area for future research. It will be important to parse the effects of the attention restoration component from the sustainable ethos component of the *Prime* domain on students' behavior and to more accurately define the characteristics of each of these components.

Another direction for future research includes the use of virtual reality (VR) to simulate different environmental conditions, paired with observations of subsequent behavior. A recent study used VR to simulate both LEED®-branded and non-branded environments and observed a variety of pro-environmental behaviors including choosing natural light over artificial light and choosing to appropriately recycle paper waste (Khashe et al., 2015). VR would be a useful initial approach for furthering the current work because of the ability to create test conditions defined by the physical attributes of the space (elements of either restorative environments or conveying a sustainable ethos).

Future work is also needed to explore the utility of the Positive Sustainable Built Environments model for explaining occupant ERBs in other building typologies. Examining other kinds of buildings is necessary as the level of design innovation, finishes, and features will differ by building type, yielding different opportunities to Prime, Permit, and Invite occupants to participate in ERBs. Academic architectural examples might include student centers and research centers that are designed to house multiple functions and serve as the public faces to alumni and donors.

Conclusion

In closing, in response to the growth and innovation of the green building industry, it is tempting to imagine that inhabiting a green building directly leads to occupants improving their environmental behaviors. In reality, many occupants may not be aware the extent to which their place of business or residence is environmentally-friendly. While there are many examples of green environments that are used explicitly to educate occupants about the environment, little is known about how people informally become aware of environmental issues and adapt their behaviors while occupying green spaces. What is known is that environmentally responsible behavior is a product of the psychological dimensions and intentions of an individual person as s/he encounters a particular situational context, which is only in part shaped by the built environment. Thus, as people move from one space to another, it is important to consider characteristics of environments that are both universally supportive of ERBs and ones that appeal to the great variety of personal dimensions people bring with them to a space. Green buildings can be an important tool in the mitigation of the effects of climate change, not simply for their environmentally sustainable features, but in their promotion of long-term ERBs. Human behavior is not only a critical component in the causes of climate change, but fortunately, can be central to solutions as well. People-environment partnerships can meet these challenges and to do so, we must design environments to support patterns of responsible environmental behaviors.

APPENDICES

APPENDIX A

PROJECT NAME

LEED BD+C: New Construction (v2009) — LEVEL, AWARDED *DATE*

SUSTAINABLE SITES		AWARDED: X / 26
SSc1	Site selection	0 / 1
SSc2	Development density and community connectivity	0 / 5
SSc3	Brownfield redevelopment	0 / 1
SSc4.1	Alternative transportation - public transportation access	0 / 6
SSc4.2	Alternative transportation - bicycle storage and changing rooms	0 / 1
SSc4.3	Alternative transportation - low-emitting and fuel-efficient vehicles	0 / 3
SSc4.4	Alternative transportation - parking capacity	0 / 2
SSc5.1	Site development - protect or restore habitat	0 / 1
SSc5.2	Site development - maximize open space	0 / 1
SSc6.1	Stormwater design - quantity control	0 / 1
SSc6.2	Stormwater design - quality control	0 / 1
SSc7.1	Heat island effect - nonroof	0 / 1
SSc7.2	Heat island effect - roof	0 / 1
SSc8	Light pollution reduction	0 / 1

WATER EFFICIENCY		AWARDED: X / 10
WEc1	Water efficient landscaping	0 / 4
WEc2	Innovative wastewater technologies	0 / 2
WEc3	Water use reduction	0 / 4

ENERGY & ATMOSPHERE		AWARDED: X / 35
EAc1	Optimize energy performance	0 / 19
EAc2	On-site renewable energy	0 / 7
EAc3	Enhanced commissioning	0 / 2
EAc4	Enhanced refrigerant Mgmt	0 / 2
EAc5	Measurement and verification	0 / 3
EAc6	Green power	0 / 2

MATERIAL & RESOURCES		AWARDED: X / 14
MRc1.1	Building reuse - maintain existing walls, floors and roof	0 / 3
MRc1.2	Building reuse - maintain interior nonstructural elements	0 / 1
MRc2	Construction waste Mgmt	0 / 2
MRc3	Materials reuse	0 / 2
MRc4	Recycled content	0 / 2
MRc5	Regional materials	0 / 2

MATERIAL & RESOURCES		CONTINUED
MRc6	Rapidly renewable materials	0 / 1
MRc7	Certified wood	0 / 1

INDOOR ENVIRONMENTAL QUALITY		AWARDED: X / 22
EQc1	Outdoor air delivery monitoring	0 / 1
EQc2	Increased ventilation	0 / 1
EQc3.1	Construction IAQ Mgmt plan - during construction	0 / 1
EQc3.2	Construction IAQ Mgmt plan - before occupancy	0 / 1
EQc4.1	Low-emitting materials - adhesives and sealants	0 / 1
EQc4.2	Low-emitting materials - paints and coatings	0 / 1
EQc4.3	Low-emitting materials - flooring systems	0 / 1
EQc4.4	Low-emitting materials - composite wood and agrifiber products	0 / 1
EQc5	Indoor chemical and pollutant source control	0 / 1
EQc6.1	Controllability of systems - lighting	0 / 1
EQc6.2	Controllability of systems - thermal comfort	0 / 1
EQc7.1	Thermal comfort - design	0 / 1
EQc7.2	Thermal comfort - verification	0 / 1
EQc8.1	Daylight and views - daylight	0 / 1
EQc8.2	Daylight and views - views	0 / 1
EQpc124	Performance-based IAQ design and assessment	REQUIRED

INNOVATION		AWARDED: X / 6
IDc1	Innovation in design	0 / 5
IDc2	LEED Accredited Professional	0 / 1

REGIONAL PRIORITY		AWARDED: X / 4
X	Credit	0 / 1
X	Credit	0 / 1
X	Credit	0 / 1
X	Credit	0 / 1

TOTAL	X / 110

40-49 Points	50-59 Points	60-79 Points	80+ Points
CERTIFIED	SILVER	GOLD	PLATINUM

Figure A.1. LEED® v2009 Scorecard

APPENDIX B

Occupant Survey

Q1 The purpose of this study is to understand the everyday environmental behaviors of students in on-campus housing. This study is being conducted by Erin Hamilton, doctoral student at the University of Michigan. The survey will take about 15 minutes to complete. You will be asked to complete this survey one more time during this academic year and to participate in a brief follow-up interview, which will be audio-recorded for note-taking purposes, and a short card-sorting activity during the Spring 2017 semester. You will not be compensated for participating in this study. However, you may choose to provide your email address at the end of the survey (which will in no way be linked to your survey responses) to be entered into a drawing for one of four $25 gift cards. Although you may not directly benefit from this study, the research will be useful for understanding how students in on-campus buildings are engaged in sustainability efforts. There are no risks associated with this study. The data collected is anonymous. Your survey responses will be identified only by a password, which you will create and use on each survey you complete but will not be linked in any way to any of your personal identifying information. Your participation in this study is voluntary. Even if you decide to participate now, you may change your mind and stop at any time. You are free to decline to answer any question for any reason. If you decide to withdraw early, the information and data you already provided may still be used in the study. Data from this research will be stored on a secure laptop with routine electronic backup and restricted access. All data will be stored for up to three years for record keeping purposes and then will be destroyed. You may request a copy of the results of this study upon completion of this project and any published results of the study will be made available to your residence hall. The University of Michigan Institutional Review Board has approved this research (eResearch ID # HUM00117575). If you have questions about your rights as a research participant, or wish to obtain information, ask questions or discuss any concerns about this study with someone other than the researcher(s), please contact the University of Michigan Health Sciences and Behavioral Sciences Institutional Review Board, 2800 Plymouth Rd. Building 520, Room 1169, Ann Arbor, MI 48109-2800, (734) 936-0933, or toll free, (866) 936-0933, irbhsbs@umich.edu. You may also contact the researchers involved with this study if you have any questions: Erin Hamilton, Principal Investigator: emham@umich.edu; Jean Wineman, Faculty Advisor: jwineman@umich.edu; and Ray De Young, Faculty Advisor: rdeyoung@umich.edu. Please print a copy of this consent page for your records. By completing this survey, you are consenting to participate. Thank you for your time and thoughts!

Q2 Before beginning the survey, please create a unique pass-code that you will use to identify yourself. The pass-code should be different than your actual name and email address. This will keep your answers anonymous and confidential. You will use this same pass-code when you complete the survey again in the Spring 2017 semester. Please choose a pass-code that will be easy for you to remember:

Q3 Enter your email address if you would like this pass-code emailed to you for your records:

Q4 What is the name of your current residence hall, that is, where you have lived since the start of the fall semester?

Q5 Which of the following two statements represents your current residence hall experience?
- ❍ This academic year is the first time I am living in this residence hall. (1)
- ❍ I have lived in this residence hall before. (2)

Q6 Which of the following best describes your current room/roommate arrangement in your residence hall?
- ❍ Single room, no roommate (1)
- ❍ Double room, shared with one roommate (2)
- ❍ Triple+ room, shared with two roommates or more (3)
- ❍ Shared suite of rooms (4)
- ❍ Other (please specify): (5) ____________________

Q7 Which of the following best describes the bathroom (restroom/shower room) you use in your residence hall?
- ❍ Private bath in my room (1)
- ❍ Shared bath within a suite of rooms (2)
- ❍ Shared community bath with my hallway or floor (3)
- ❍ Other (please specify): (4) ____________________

Q8 Other than your residence hall, is there one particular campus building in which you spend most of your time (for an activity such as work, classes, or studying)?

- ❍ Yes (1)
- ❍ No (2)

Display This Question:

If Other than your residence hall, is there one particular campus building in which you spend most of your time (for an activity such as work, classes, or studying)? Yes Is Selected

Q9 Please type the name of this campus building in which you spend most of your time (for an activity such as work, classes, or studying):

Q10 How much do you agree or disagree with the following statements?

	Completely disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Completely agree (5)
The earth's climate is changing. (1)	❍	❍	❍	❍	❍
Climate change is largely the result of human behaviors, which release carbon dioxide into the atmosphere. (2)	❍	❍	❍	❍	❍
Climate change is the result of natural phenomena, not the product of human behaviors. (3)	❍	❍	❍	❍	❍
I could explain the topic of climate change to someone who didn't know about it - what's causing it or not, its potential consequences, etc. (4)	❍	❍	❍	❍	❍

Q11 This set of questions will ask you about behaviors that use energy.
Q12 How often do you typically do the following behaviors?

	Never (1)	Very Infrequently (2)	Once in a while (3)	Sometimes (4)	Often (5)	Most of the time (6)	Always (7)	Not Applicable (8)
Set thermostat (heat) to 68°F or lower during cool or cold weather (1)	❍	❍	❍	❍	❍	❍	❍	❍
Set thermostat (air conditioner) to 78°F or higher during warm or hot weather (2)	❍	❍	❍	❍	❍	❍	❍	❍
Turn off lights when I leave my bedroom (3)	❍	❍	❍	❍	❍	❍	❍	❍
Leave the lights on when I leave a common room (4)	❍	❍	❍	❍	❍	❍	❍	❍
Unplug small electrical appliances (e.g. coffee pot, toaster, chargers) when not using them (5)	❍	❍	❍	❍	❍	❍	❍	❍

Use the power saving settings on my computer (6)	❍	❍	❍	❍	❍	❍	❍	❍
Leave my computer on when I'm not using it (7)	❍	❍	❍	❍	❍	❍	❍	❍
Use a motion sensor / "smart" power strip (8)	❍	❍	❍	❍	❍	❍	❍	❍
Override the automatic light sensors in rooms by flipping a switch or pressing a button (9)	❍	❍	❍	❍	❍	❍	❍	❍
Adjust my clothing to be comfortable indoors rather than adjust the thermostat (10)	❍	❍	❍	❍	❍	❍	❍	❍
Take the stairs instead of the elevator (11)	❍	❍	❍	❍	❍	❍	❍	❍

Q13 How much do you know about the following?

	Nothing (1)	A little (2)	A fair amount (3)	A lot (4)	I know more than most of my peers. (5)
Ways to use less energy in my residence hall (1)	❍	❍	❍	❍	❍
Features in my residence hall that are intended to save energy (2)	❍	❍	❍	❍	❍
How the amount of energy I use in my daily life compares to that of the average college student (3)	❍	❍	❍	❍	❍
If my residence hall is more or less energy efficient than other residence halls on campus (4)	❍	❍	❍	❍	❍

Q14 List up to 3 features of your residence hall that help to conserve energy, or you can write "I don't know":

Q15 Energy Use Intensity (EUI) is like Miles per Gallon for buildings. EUI measures a building’s total energy use per square foot. Generally, a low EUI indicates a building that is energy efficient. Please indicate if you think that the following actions can help improve your university's Energy Use Intensity. (Check all that apply).

- ❑ Turning off lights (1)
- ❑ Washing clothes in cold water (2)
- ❑ Taking shorter showers (3)
- ❑ Eating a vegetarian diet (4)
- ❑ Eating local or organic produce (5)
- ❑ Sharing printing resources (6)
- ❑ Using CFL or LED light bulbs (7)
- ❑ Using a smart power strip (8)
- ❑ Unplugging devices when not in use (9)
- ❑ Recycling paper/plastic/metal (10)

Q16 These questions will ask you about your behaviors concerning water usage...

Q17 How often do you typically do the following behaviors?

	Never (1)	Very Infrequently (2)	Once in a while (3)	Sometimes (4)	Often (5)	Most of the time (6)	Always (7)	Not Applicable (8)
Wash partial loads of laundry (1)	❍	❍	❍	❍	❍	❍	❍	❍
Leave the water running while soaping my hands (2)	❍	❍	❍	❍	❍	❍	❍	❍
Shower longer than 5 minutes (3)	❍	❍	❍	❍	❍	❍	❍	❍
Shower/bathe less frequently (4)	❍	❍	❍	❍	❍	❍	❍	❍
Turn off the water while brushing teeth (5)	❍	❍	❍	❍	❍	❍	❍	❍
Flush the toilet when I use it (6)	❍	❍	❍	❍	❍	❍	❍	❍
Wear clothing items more than once between washing (7)	❍	❍	❍	❍	❍	❍	❍	❍
Flush the toilet to dispose of an insect or used tissue (8)	❍	❍	❍	❍	❍	❍	❍	❍

Q18 How much do you know about the following?

	Nothing (1)	A little (2)	A fair amount (3)	A lot (4)	I know more than most of my peers. (5)
Ways to use less water (1)	❍	❍	❍	❍	❍
Features of my residence hall that use water efficiently (2)	❍	❍	❍	❍	❍
How the amount of water I use in my daily life compares to that of the average college student (3)	❍	❍	❍	❍	❍
If my residence hall uses water more or less efficiently than other residence halls on campus (4)	❍	❍	❍	❍	❍

Q19 List of up to 3 features of your residence hall that help to conserve water, or you can write, "I don't know":

Q20 Actions have different environmental impacts. Please rank the following actions according to their impact on water savings over their life cycle. (#1 = smallest savings; #5 = largest savings).

_______ using low-flow shower heads (1)
_______ reducing shower time (2)
_______ turning off the water while brushing teeth (3)
_______ only using the dishwasher or washing machines for full loads (4)
_______ flushing only when necessary (not to dispose of insects or tissues) (5)

Q21 The next few questions are about materials and resources...

Q22 How often do you typically do the following behaviors?

	Never (1)	Very Infrequently (2)	Once in a while (3)	Sometimes (4)	Often (5)	Most of the time (6)	Always (7)	Not Applicable (8)
Print single-sided (1)	❍	❍	❍	❍	❍	❍	❍	❍
Recycle bottles, containers, and paper products (2)	❍	❍	❍	❍	❍	❍	❍	❍
Use a reusable water bottle, coffee cup, travel mug, etc. (3)	❍	❍	❍	❍	❍	❍	❍	❍
Use disposable bags for grocery/supplies shopping (4)	❍	❍	❍	❍	❍	❍	❍	❍
Reuse paper for scrap paper (5)	❍	❍	❍	❍	❍	❍	❍	❍
Share resources with others rather than buying my own (6)	❍	❍	❍	❍	❍	❍	❍	❍
Try to repair broken items before repurchasing the item (7)	❍	❍	❍	❍	❍	❍	❍	❍

Shop in a second-hand store or on-line site such as Craigslist, when I have to buy something, rather than purchasing new (8)	❍	❍	❍	❍	❍	❍	❍	❍
Compost food scraps (9)	❍	❍	❍	❍	❍	❍	❍	❍
Save any small plastic bags I receive for reuse (10)	❍	❍	❍	❍	❍	❍	❍	❍

Q23 How much do you know about the following?

	Nothing (1)	A little (2)	A fair amount (3)	A lot (4)	I know more than most of my peers. (5)
How to recycle larger items that cannot go into a recycling bin in my residence hall (1)	❍	❍	❍	❍	❍
Which materials can be recycled on campus (2)	❍	❍	❍	❍	❍
Which materials in my residence hall are made from recycled content, or renewable resources (3)	❍	❍	❍	❍	❍
How to compost on my campus (4)	❍	❍	❍	❍	❍

Q24 List up to the 3 features of your residence hall that are evidence of a conservation of material resources, or you can write "I don't know":

Q25 Please indicate if you think the following items can be recycled or donated at your university by checking all that apply.

- ❑ White paper (1)
- ❑ Newspaper and magazines (2)
- ❑ Corrugated cardboard (3)
- ❑ Tissues and paper towels (4)
- ❑ Plastic bottles (5)
- ❑ Glass bottles (6)
- ❑ Soda cans (7)
- ❑ Paper coffee cups (8)
- ❑ Styrofoam cups (9)
- ❑ Batteries (10)
- ❑ Cell phones (11)
- ❑ Computers (12)
- ❑ Toner/ink cartridges (13)
- ❑ Small appliances (14)
- ❑ Clothes (15)
- ❑ Light bulbs (16)
- ❑ Linens (17)

Q26 The products we use and discard have different environmental impacts. Please rank the following actions according to their impact on resource consumption. (#1 = smallest consumption; #5 = largest consumption).

_______ Using a stainless steel travel mug 2 times before recycling it (1)
_______ Using 45 disposable paper cups, then recycling them (2)
_______ Using 45 disposable styrofoam cups, then throwing them away (3)
_______ Using a stainless steel travel mug 45 times before recycling it (4)
_______ Using 2 disposable paper cups, then recycling them (5)

Q27 Now we're going to ask you about your travel behaviors...

Q28 How often do you use the following modes of transportation to get to on-campus locations?

	Never (1)	Very Infrequently (2)	Once in a while (3)	Sometimes (4)	Often (5)	Most of the time (6)	Always (7)	Not Applicable (8)
Drive a car by myself (1)	❍	❍	❍	❍	❍	❍	❍	❍
Park and ride the bus (2)	❍	❍	❍	❍	❍	❍	❍	❍
Walk / Use a wheelchair (3)	❍	❍	❍	❍	❍	❍	❍	❍
Bike (4)	❍	❍	❍	❍	❍	❍	❍	❍
Campus bus (5)	❍	❍	❍	❍	❍	❍	❍	❍
City bus (6)	❍	❍	❍	❍	❍	❍	❍	❍
Carpool (self-organized with friends or coworkers) (7)	❍	❍	❍	❍	❍	❍	❍	❍
Motorcycle, moped, or scooter (8)	❍	❍	❍	❍	❍	❍	❍	❍
Skateboard/rollerblade (9)	❍	❍	❍	❍	❍	❍	❍	❍

Q29 How often do you use the following modes of transportation to get to off-campus locations?

	Never (1)	Very Infrequently (2)	Once in a while (3)	Sometimes (4)	Often (5)	Most of the time (6)	Always (7)	Not Applicable (8)
Drive a car by myself (1)	❍	❍	❍	❍	❍	❍	❍	❍
Park and ride the bus (2)	❍	❍	❍	❍	❍	❍	❍	❍
Walk / Use a wheelchair (3)	❍	❍	❍	❍	❍	❍	❍	❍
Bike (4)	❍	❍	❍	❍	❍	❍	❍	❍
Campus bus (5)	❍	❍	❍	❍	❍	❍	❍	❍
City bus (6)	❍	❍	❍	❍	❍	❍	❍	❍
Carpool (self-organized with friends or coworkers) (7)	❍	❍	❍	❍	❍	❍	❍	❍
Motorcycle, moped, or scooter (8)	❍	❍	❍	❍	❍	❍	❍	❍
Skateboard/rollerblade (9)	❍	❍	❍	❍	❍	❍	❍	❍

Q30 How much do you know about the following in your current town?

	Nothing (1)	A little (2)	A fair amount (3)	A lot (4)	I know more than most of my peers. (5)
City bus schedules, routes (1)	❍	❍	❍	❍	❍
Campus bus schedules, routes (2)	❍	❍	❍	❍	❍
Biking around town (bike lanes, rules of the road, etc.) (3)	❍	❍	❍	❍	❍
Renting a car by the hour (e.g. ZipCar) (4)	❍	❍	❍	❍	❍
City bike program (5)	❍	❍	❍	❍	❍
Transportation modes that produce the least carbon emissions (6)	❍	❍	❍	❍	❍

Q31 List up to 3 features of your residence hall that impact people's travel behavior, or you can write "I don't know":

Q32 The ways we travel have different environmental impacts. Please rank the following scenarios according to their environmental impact on carbon emissions. (#1 = smallest impact; #5 = largest impact)

_______ Riding a city bus off-campus to buy groceries twice a week (1)
_______ Walking to school every day (2)
_______ Driving an automobile every day to work (3)
_______ Flying in an airplane one time across country (4)
_______ Bicycling between classes multiple times per day (5)

Q33 The next few questions are going to ask you to think about things that are important to you and why you participate in the activities you do...

Q34 How important or unimportant is each of the following values as a guiding principle in your life? Provide your answer by sliding the icon along the scale provided:

_______ Having an impact on people and events (1)
_______ Being in harmony with other living species (2)
_______ Working for the welfare of others (3)
_______ Preserving nature (4)
_______ Leading a group of people (5)
_______ Caring for the weak (6)
_______ Having the material possessions I choose (7)
_______ Making sure everyone has equal opportunities (8)
_______ Preventing pollution (9)
_______ Working for peace in the world (10)
_______ Having influence amongst my social group (11)
_______ Making a high salary in my field (12)
_______ Correcting injustices locally or abroad (13)
_______ Fitting in with nature (14)
_______ Protecting natural resources (15)

Q35 The following is a list of reasons people might participate in a variety of activities. How motivating would each of the following items be in getting you to participate in any activity? Provide your answer by sliding the icon along the scale provided:

_______ Meet new people (1)
_______ Spend time for a good purpose (2)
_______ Learn new skills (3)
_______ Feel good about myself (4)
_______ Chance to be outdoors (5)
_______ Try out a new product or gadget (6)
_______ Help others do something important (7)
_______ Find ways to avoid waste (8)
_______ Contribute to my spirituality (9)
_______ Learn about my surroundings (10)
_______ Protect natural places from disappearing (11)
_______ Have a story to tell people (12)
_______ Chance to reflect (13)
_______ Use the latest technology (14)
_______ Do something that nobody else is doing (15)
_______ Improve my outlook on life (16)
_______ Make life more simple (17)
_______ Discover new things I'm not yet competent at doing (18)
_______ Influence how society solves problems (19)
_______ Care for the land (20)
_______ Chance to have a leadership role (21)
_______ See familiar faces (22)
_______ Help restore natural areas (23)
_______ Do something that helps bring order to the world (24)
_______ Opportunity to try something new (25)
_______ Consume a minimum amount of resources (26)
_______ Use something borrowed or second-hand rather than buying new (27)
_______ Make the environment better for others (28)

Q36 Starting a new school year and moving into a new building gives you the opportunity to reinvent yourself. Who do you see yourself becoming over this academic year? Complete this sentence by indicating the degree to which the following phrases do or do not describe you: "I intend to be someone who is devoted to..."

_______ Social justice (1)
_______ Health and well-being (2)
_______ Professional development (3)
_______ Environmentalism (4)
_______ Entrepreneurialism (5)
_______ Creativity/Artistic expression (6)
_______ Athleticism / Physical fitness (7)
_______ Earning income (8)
_______ Academic success (9)
_______ Social relationships (10)
_______ Spiritual growth (11)
_______ Volunteerism (12)

Q37 Almost done! Just a few more questions...

Q38 How old are you?

Q39 Select your identified gender:

- Female (1)
- Male (2)
- Trans (3)
- Other (please specify): (4) ____________________
- Decline to provide information (5)

Q40 In what year of your undergraduate degree are you?

- First-year (1)
- Second-year (2)
- Third-year (3)
- Fourth-year (4)
- Fifth-year (5)
- Other (please specify): (6) ____________________
- None of the above, I'm a graduate student. (7)

Q41 What is your major at this time?

Q42 Are you a U.S. student or an international student?

- U.S. Student (1)
- International Student (2)

Display This Question:

If Are you a U.S. student or an international student? International Student Is Selected

Q43 Which of the following best describes your country of origin?

- ❍ China (including Hong Kong) (1)
- ❍ India (2)
- ❍ Other Asian countries (NOT China or India) (3)
- ❍ Europe (4)
- ❍ Mexico, Latin America, Central America, the Caribbean (5)
- ❍ Other (please specify): (6) ____________________

Q44 YOU'RE DONE! Now that you have completed this survey, you are eligible to win one of four $25 gift cards available to students in your residence hall. Do you wish to be included in the drawing?

- ❍ Yes, please include me in the drawing. My email address is: (1) ____________________
- ❍ No, thanks. Do not include me in the drawing. (2)

APPENDIX C
Survey Invitations: Email Text Sent to Students

Fall Survey Invitation #1 (Initial)

Dear student,

I hope you are enjoying a smooth start to your semester and are settling into X Residence Hall at the University of X. My name is Erin Hamilton and I am a PhD student of the University of Michigan. I'd like to invite you to participate in a research study that looks at the everyday environmental behaviors of students in on-campus housing.

I am asking you to participate because you are a new resident of your on-campus residence hall. The study will involve a computer survey about your environmental behaviors and your residence hall, which should take about 15 minutes to complete. You will be asked to complete this survey one more time during this academic year and to participate in a brief follow-up interview and a short card-sorting activity during the Spring 2017 semester. After you complete the survey, you may choose to provide your email address (which will in no way be linked to your survey responses) for a chance to win one of four, $25 gift cards!

If you have any questions regarding the content of this research study or the methods, please feel free to contact me at emham@umich.edu.

Click on this LINK to be taken to the survey.

Thank you for your time!

Sincerely,

Erin Hamilton

Fall Survey Invitation #2 (Follow-up)

Dear X Residents,

Thank you to those of you who have taken the time to fill out the online survey about every day environmental behaviors of students living in your dorm. If you haven't filled out the survey yet, there's still time! It should take no longer than 15 minutes to complete and you can win one of four $25 gift cards. Your response to this survey is super important to this research and I really appreciate your time and participation!

If you have any questions regarding the content of this research study or the methods, please feel free to contact me at emham@umich.edu

Click on this LINK to be taken to the survey.

Thank you for your time!

Sincerely,

Erin Hamilton

Fall Survey Invitation #3 (Final)

Dear X Residents,

Thank you so much to everyone has taken the online survey about every day environmental behaviors. If you haven't filled out the survey yet, this is the last call! It should take no longer than 15 minutes to complete and you can win one of four $25 gift cards. The survey will close on X DATE.

If you have any questions regarding the content of this research study or the methods, please feel free to contact me at emham@umich.edu.

Click on this LINK to be taken to the survey.

Thank you for your time!

Sincerely,

Erin Hamilton

Spring Survey Invitation #1 (Initial)

Dear student,

My name is Erin Hamilton and I am a PhD student of the University of Michigan. I'd like to invite you to participate in two research opportunities that look at the everyday environmental behaviors of students in on-campus housing.

I am asking you to participate because you are a first-time resident of your on-campus residence hall this academic year. The study will involve a computer survey about your environmental behaviors and your residence hall, which should take about 15 minutes to complete. After you complete the survey, you may choose to provide your email address (which will in no way be linked to your survey responses) for a chance to win one of four, $25 gift cards!

I'd also like to invite you to participate in a **follow-up activity with the researcher during the week of March 6-10**, which involves a card-sorting activity about your residence hall and labeling some building features on maps with stickers. The two activities should take no longer than 45 minutes to complete. The researcher will provide directions for each of the tasks and you will complete the tasks individually. During your session, there will be free food**. If you complete the online survey and you participate in the in-person card-sorting and mapping tasks, you will be entered into a drawing for an additional $100 gift card.**

If you have any questions regarding the content of this research study or the methods, please feel free to contact me at emham@umich.edu.

Click on this LINK to be taken to the survey. Click on this LINK to sign up for the card-sorting activity and free food!

Thank you for your time!

Sincerely,

Erin Hamilton

Spring Survey Invitation #2 (Follow-up)

Dear X Residents,

Thank you to those of you who have taken the time to fill out the online survey about every day environmental behaviors in your residence hall. If you haven't filled out the survey yet, there's still time! It should take no longer than 15 minutes to complete and you can win one of four $25 gift cards. Your response to this survey is super important to this research and I really appreciate your time and participation!

Second, don't forget to sign up to participate in a **follow-up activity with the researcher during the week of March 6-10 in your residence hall.** There will be free food and a fun card-sorting activity, which should take no longer than 45 minutes. **If you complete the online survey and you participate in the in-person card-sorting activity, you will be entered into a drawing for an additional $100 gift card.**

If you have any questions regarding the content of this research study or the methods, please feel free to contact me at emham@umich.edu.

Click on this LINK to be taken to the survey. Click on this LINK to sign up for the card-sorting activity and free food!

Thank you for your time!

Sincerely,

Erin Hamilton

Spring Survey Invitation #3 (Follow-up)

Dear X Residents,

Thank you so much to everyone has taken the online survey about every day environmental behaviors. If you haven't filled out the survey yet, this is the last call! It should take no longer than 15 minutes to complete and you can win one of four $25 gift cards. The survey will remain open until X DATE.

Second, don't forget to participate in a **follow-up activity with the researcher on March 7, 9:00 am – 12:00 pm in Classroom 5.** There will be free food and a fun card-sorting activity, which should take no longer than 45 minutes. **<u>If you complete the online survey and you participate in the in-person card-sorting activity, you will be entered into a drawing for an additional $100 gift card.</u>**

If you have any questions regarding the content of this research study or the methods, please feel free to contact me at emham@umich.edu.

Click on this LINK to be taken to the survey. Click on this LINK to sign up for the card-sorting activity and free food! You can also drop-in during the hours listed above.

Thank you for your time!

Sincerely,

Erin Hamilton

Appendix D.

Scoring of Building Characteristics According to Positive Sustainable Built Environments (PSBE) Model

Table D-1. Building A.1 PSBE Scores

A.1 (Green Hall)		ENERGY		WATER		MATERIALS		TRAVEL		PRIME
		PERMIT	INVITE	PERMIT	INVITE	PERMIT	INVITE	PERMIT	INVITE	
Public Space	Building Exterior	0	0	0	0	0	0	3	1	3
	Lobby Interior	1	0	0	0	3	0	0	1	2
Semi-Public/ Semi-Private Space	Special Event Lounges	3	0	0	0	2	0	0	0	3
	Kitchen	1	0	1	0	0	0	0	0	0
	Computer Room	2	0	0	0	1	1	0	0	1
	Laundry	2	0	1	0	1	0	0	0	1
	Hallways	1	0	0	0	1	0	0	0	2
	Resident Lounge/TV	3	0	0	0	0	0	0	0	2
	Resident Study Room	2	0	0	0	0	0	0	0	1
	Trash/Recycling	1	0	0	0	3	3	0	0	0
	Bath/Shower Room	1	0	3	2	1	1	0	0	1
Private Space	Private Bedroom	3	0	0	0	1	0	0	0	1

Table D-2. Building A.2 PSBE Scores

A.2 (Green Hall)		ENERGY		WATER		MATERIALS		TRAVEL		PRIME
		PERMIT	INVITE	PERMIT	INVITE	PERMIT	INVITE	PERMIT	INVITE	
Public Space	Building Exterior	0	0	0	0	0	0	3	2	3
	Lobby Interior	2	1	0	0	3	0	0	1	2
Semi-Public/ Semi-Private Space	Special Event Lounges	3	0	0	0	2	0	0	0	2
	Kitchen	3	0	1	0	2	0	0	0	0
	Computer Room	3	0	0	0	0	0	0	0	1
	Laundry	3	0	1	0	2	0	0	0	2
	Hallways	1	1	0	0	1	0	0	0	2
	Resident Lounge/TV	3	0	0	0	2	0	0	0	2
	Resident Study Room	3	0	0	0	0	0	0	0	2
	Trash/Recycling	1	0	0	0	3	2	0	0	0
Private Space	Bath/Shower Room	1	1	2	1	1	0	0	0	0
	Private Bedroom	3	0	0	0	1	0	0	0	1

Table D-3. Building A.3 PSBE Scores

A.3 (Conventional Hall)		ENERGY		WATER		MATERIALS		TRAVEL		PRIME
		PERMIT	INVITE	PERMIT	INVITE	PERMIT	INVITE	PERMIT	INVITE	
Public Space	Building Exterior	0	0	0	0	0	0	3	0	2
	Lobby Interior	3	0	0	0	2	0	0	1	2
Semi-Public/ Semi-Private Space	Special Event Lounges									
	Kitchen	3	1	1	0	1	0	0	0	1
	Computer Room	3	0	0	0	1	1	0	0	1
	Laundry	3	0	1	0	0	0	0	0	2
	Hallways	2	0	0	0	2	0	0	0	1
	Resident Lounge/TV	3	0	0	0	1	0	0	0	1
	Resident Study Room	3	0	0	0	0	0	0	0	1
	Trash/Recycling	1	0	0	0	3	3	0	0	0
	Bath/Shower Room	2	2	2	3	1	1	0	0	1
Private Space	Private Bedroom	3	1	0	0	1	0	0	0	1

Table D-4. Building B.1 PSBE Scores

B.1 (Green Hall)		ENERGY		WATER		MATERIALS		TRAVEL		PRIME
		PERMIT	INVITE	PERMIT	INVITE	PERMIT	INVITE	PERMIT	INVITE	
Public Space	Building Exterior	0	0	0	0	0	0	3	1	3
	Lobby Interior	0	0	0	0	3	0	0	0	3
Semi-Public/ Semi-Private Space	Special Event Lounges									
	Kitchen	1	0	1	0	1	2	0	0	1
	Computer Room	3	0	0	0	2	2	0	0	2
	Laundry	2	0	1	0	0	0	0	0	1
	Hallways	1	1	0	0	1	1	0	0	3
	Resident Lounge/TV	3	0	0	0	2	2	0	0	3
	Resident Study Room	3	0	0	0	2	2	0	0	2
	Trash/Recycling	2	0	0	0	3	3	0	0	1
	Bath/Shower Room	1	0	2	0	2	2	0	0	0
Private Space	Private Bedroom	3	0	0	0	2	2	0	0	1

Table D-5. Building B.2 PSBE Scores

B.2 (Green Hall)		ENERGY		WATER		MATERIALS		TRAVEL		PRIME
		PERMIT	INVITE	PERMIT	INVITE	PERMIT	INVITE	PERMIT	INVITE	
Public Space	Building Exterior	0	0	0	0	0	0	3	1	2
	Lobby Interior	1	0	0	0	0	0	0	1	3
Semi-Public/ Semi-Private Space	Special Event Lounges	2	0	0	0	3	2	0	1	3
	Kitchen	3	0	1	0	2	2	0	0	1
	Computer Room									
	Laundry	2	0	1	0	1	2	0	0	2
	Hallways	1	0	0	0	1	1	0	1	2
	Resident Lounge/TV	3	0	0	0	2	2	0	0	3
	Resident Study Room	3	0	0	0	2	2	0	0	1
	Trash/Recycling	1	0	0	0	3	3	0	0	0
	Bath/Shower Room	2	0	3	3	1	1	0	0	1
Private Space	Private Bedroom	3	0	0	0	2	2	0	0	1

Table D-6. Building B.3 PSBE Scores

B.3 (Conventional Hall)		ENERGY		WATER		MATERIALS		TRAVEL		PRIME
		PERMIT	INVITE	PERMIT	INVITE	PERMIT	INVITE	PERMIT	INVITE	
Public Space	Building Exterior	0	0	0	0	0	0	3	1	3
	Lobby Interior	1	0	0	0	3	2	0	0	2
Semi-Public/ Semi-Private Space	Special Event Lounges	3	0	0	0	2	0	0	0	2
	Kitchen	1	0	1	0	1	3	0	0	1
	Computer Room	2	0	0	0	2	2	0	0	1
	Laundry	2	0	1	0	1	1	0	0	1
	Hallways	0	0	0	0	0	0	0	0	2
	Resident Lounge/TV	3	0	0	0	2	2	0	0	1
	Resident Study Room	3	0	0	0	2	2	0	0	2
	Trash/Recycling	1	0	0	0	3	3	0	0	0
Private Space	Bath/Shower Room	1	0	2	0	0	1	0	0	1
	Private Bedroom	3	0	0	0	2	2	0	0	1

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