

Sustainable accommodations affording sustainable behaviours: a mixed method investigation

PhD Thesis

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Adrienn Rokosni

Abstract

The study develops insight on how architecture materialized in sustainable accommodations may afford environmentally sustainable occupant behaviours which if not supported may significantly contribute to the environmental impact and greenhouse gas emissions of sustainable buildings and potentially hinder the contribution of architecture to climate change mitigation. The goal is to address the knowledge gap and feed information back to architecture on ways to better support sustainable occupant behaviours by sustainable accommodation design.

Knowledge is built by adopting the Theory of Affordances as embraced by design through the concept of Perceived Affordances suggesting that sustainable occupant behaviours may be afforded by the sustainable accommodation when occupant-perceived affordances match architect-designed affordances. Perceived affordances are explored qualitatively via 20, face to face, in-depth, semi-structured interviews, and quantitatively via a survey with 222 respondents, performed with occupants of BREEAM certified accommodations across four UK sites. Designed affordances are explored via face to face, in-depth, semi-structured interviews with the architects of the same accommodations. The match between the designed and perceived affordances are identified by analytically comparing the results of the occupant studies with the results of the architect studies.

The overall results reveal that there are gaps and overlaps in how occupants perceive the sustainable accommodation affords sustainable behaviour and how architects intend to afford those behaviours via their designs. More specifically, occupants report more sustainable behaviours afforded by the sustainable accommodations when their needs are perceived to be supported by the design features. As far as design professionals are concerned, architects reveal considering and intending to support occupant needs and behaviours via their designs. Nevertheless, while certain needs are conceptualized by architects in manners that cover occupant-expressed needs and their integration in design may promote sustainable occupant behaviours, other needs are missing from architects' agenda potentially obstructing design in affording related sustainable occupant behaviours.

The principal contribution of the study to research knowledge is the revelation that behaviourally sustainable design is also need supportive design while highlighting the architectural best practices and pitfalls to promoting sustainable use by design. An additional, methodological contribution is embodied by the newly developed Feature-Need-Behaviour (FNB) table that allows capturing and more importantly comparing occupant perceptions with architect intentions and facilitates the research of sustainable behaviour affordances of sustainable buildings. For architectural practice, the thesis proposes adopting the FNB framework as an informative thinking pattern during design of sustainable accommodations in order to facilitate catering for behavioural sustainability.

Future research is proposed to extend the scope of studied occupant behaviours and develop a sample fit for generalizing the findings for the UK. Additionally, it is recommended that testing the results of the present study via quasi-experiments may confirm causality between needs supportive character of design and sustainable occupant behaviour, opening the way for recognizing the sustainability benefits of needs supportive design in policy, regulations, and prevalent sustainable certification systems.

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Abbreviations

ABC	– Stern’s “Attitude – Behaviour – Context” model
BREEAM	– Building Research Establishment Environmental Assessment Method
CGT	– Charmazian Grounded Theory
CHP	– Combined Heat and Power
CLT	– Cross-laminated Timber
DEFRA	– Department for Environment, Food and Rural Affairs
DfBC	– Design for Behaviour Change
DfSB	– Design for Sustainable Behaviour
ESB	– Environmentally Significant Behaviour
FNB	– Feature-Need-Behaviour
GT	– Grounded Theory
LED	– Light Emitting Diode
LEED	– Leadership in Energy and Environmental Design
MOA	– Motivation-Opportunity-Ability model
PEF	– Personal Ecological Footprint
PIR	– Passive infrared sensor
POE	– Post Occupancy Evaluations
PVC	– Photovoltaic Cell
RIBA	– Royal Institute of British Architects
SPT	– Social Practice Theory
TA	– Thematic Analysis
TIP	– Theory of planned behaviour

Locations:

MH	– Mountain Halls
DDH	– Daniel Defoe Hall
PPQ	– Peel Park Quarters
CC	– Crome Court

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1. Introduction

1.1. Background

1.1.1. Climate change

On 12 December 2015, the leaders of the world unanimously agreed in Paris, that climate change is of human origin and human behaviour needs to change to avoid global warming of a magnitude that may potentially be catastrophic to humanity. The main vehicle identified was the reduction of greenhouse gas emission from fossil fuel intensive human activity which is steadily increasing global average temperatures on Earth. Policies aiming to reduce fossil fuel use, or technological changes that move towards renewable energy sources are some of the top-down instruments that are expected to get humanity closer to the goals of the Paris Agreement. This however needs to be met by a bottom-up wave of individually performed behaviours and actions that are more environmentally aware and thus more sustainable.

In the UK, the need for matching policy and technology with individual behaviour is underlined by the phenomenon that although recent technological advances project a reduction in energy use, paradoxically domestic energy consumption remains relatively unchanged or may even increase. For instance, in the first quarter of 2015 the UK energy consumptions was 6% higher than in the same period of 2014 with domestic energy consumption component jumping almost 11%. (DECC, 2015b). One possible explanation for this paradox is that the energy savings, expected to be delivered by new, less energy heavy technologies are overridden by the increased usage of new devices, counterbalancing the initially expected savings (DECC, 2015a). Therefore, in order to ensure increasing resource usage is not denying gains from most technological advances, understanding and supporting more sustainable behaviour is becoming a pressing goal (Clarke, 2013; Hoffman & Henn, 2008; Leaman & Bordass, 2001).

1.1.2. Sustainable buildings

One major area of focus in mitigating climate change is the building industry and the resulting building stock which are responsible for around 39% of greenhouse gas emissions arising from energy consumption (GABC, 2018). In the UK, buildings are responsible for about 34% of total greenhouse gas emissions and therefore significantly contribute to climate change (Committee on Climate Change, 2015). Architecture has already made considerable effort and progress towards reducing the emissions of new constructions and lowering their resource and energy consumption, with sustainable buildings being the most tangible manifestation.

It is difficult to clearly define what exactly a sustainable building is, but the commonly accepted definitions refer to buildings that are environment and resource considerate both in structure and in process throughout the building life cycle (Berardi, 2013). Although the definitions provide some hints on the characteristics of a sustainable building, do not clarify how substantial sustainability consideration must be, where a sustainable building might start and what exactly defines whether a building is legitimate to be called sustainable or not. To tackle this issue, sustainable buildings are often assessed based on various international design standards, the UK Building Research Establishment and Environmental Assessment Method (www.breeam.com) – hereafter abbreviated as BREEAM, the US Leadership in Energy Efficient Design (<https://new.usgbc.org/leed>) – hereafter abbreviated as LEED, or the German Passivhouse standard (<http://www.passivhaustrust.org.uk/>), to name but a few. These benchmarks mainly stipulate technological parameters to be achieved for the building to be considered sustainable, corresponding to the top-down approach, while the bottom-up approach of supporting and promoting sustainable occupant behaviour seems to be missing from the design requirements of these coveted certifications.

However, just as in the case of sustainable technologies mentioned above, technologically sustainable buildings do not deliver consistently the expected environment-considerate performance. In the UK, empirical studies indicate that there is often a gap between the designed, expected and real, actual performance of the building also called the building performance gap (Leaman & Bordass, 2001), which was found to be sometimes as high as 400% of the expected performance (Gupta & Gregg, 2016), and may be due to various factors, with recent studies attributing up to 80% of the gap to human behaviour (van Dronkelaar et al. 2016). This means that the architecture of sustainably certified buildings may be failing to contribute to the global effort of climate change mitigation, due to occupant behaviour and building interactions.

The findings underlining the prevalent underperformance of sustainable buildings further underpin the previously mentioned proposal of complementing top down, technological approaches with bottom up, behaviour-focused approaches and highlight its relevance in the context of sustainable buildings as well. The idea is well phrased by Williams & Dair insisting that besides technical and material sustainability, the buildings also need to deliver behavioural sustainability (Williams & Dair, 2007) to achieve a truly sustainable state. From the perspective of architecture, this means that it is not enough to design sustainable buildings which are equipped with sustainable technologies, but it is also crucial to ensure that the building, and its features and incorporated technologies are used in a sustainable, environmentally considerate way.

1.1.3. Supporting sustainable behaviour by architectural design

Architecture has been credited with the ability to shape health and safety related behaviour, to influence academic and professional performance, to promote socially desirable behaviour, facilitate wayfinding or even to reduce crime (Augustin et al., 2009; Crowe, 2000; Kleedwell, 2017; Kopec, 2012; Sternberg, 2009; Ulrich, 1984) as will be briefly shown in the 'Literature review' chapter. When it comes to sustainable behaviours, recent studies theorise that sustainable buildings and the way the physical elements and features are designed and integrated within the building may have a significant influence on occupants environmentally relevant behaviours and building interactions (Delzende et al., 2017; O'Brien & Gunay, 2014). This suggests that architecture might be in a privileged position to also support sustainable occupant behaviours and building interactions by sustainable buildings. However, empirical investigations are scarce on how architecture materialized as sustainable buildings may actually shape sustainable occupant behaviour.

The present investigation comes to address this knowledge gap. In its quest to generate knowledge, it embraces the concept of Perceived Affordances (Norman, 2002) adopted from one of the most seminal theories of Perceptual psychology, the Theory of Affordances (Gibson, 1977). The concept of Perceived Affordance suggests that an artefact is used in the designer-intended way if the perceived affordance, namely the actions perceived by the user to be possible on an object or what is the right way of using it for a user, is synchronised with the designed affordance, which is the way the object was intended by the designer to be used and interacted with. In the context of sustainable buildings, this means that sustainable buildings may be used in an intended sustainable way, when the occupant perceived sustainable behaviour affordance meets the designed affordance intended by the architects. However, there is little literature on how the designed affordances match the perceived affordances in sustainable buildings, or even on how occupant perceive the affordances and how architects intend to afford sustainable occupant behaviours. Therefore, the present study investigates how the architecture materialized as sustainable buildings shape environmentally sustainable occupant behaviours by building insight on perceived and designed affordances in sustainable buildings and juxtaposing these two sets of affordances.

1.2. Aim and objectives

The aim of the study is to increase understanding through the lenses of occupants and of architects on how the architecture of sustainable buildings may shape sustainable occupant behaviours and building interactions. The goal beyond addressing the gap in knowledge, is to feed

information back to architecture and to aid the architecture of sustainable buildings to better contribute to the global effort of reducing climate change by delivering not just technologically but also behaviourally sustainable buildings.

The objectives supporting the aim are:

- to understand occupants' perceptions of ways the architectural elements and features of sustainable student accommodations afford environmentally sustainable behaviours and building interactions;
- to explore architects' intentions on enabling and promoting environmentally sustainable occupant behaviours by design;
- to reveal overlaps and gaps between occupants' perceptions and architects' intentions;
- to identify opportunities architecture could harness to better promote environmentally supportive occupant behaviours and occupant-building interactions in sustainable student accommodations;

1.3. Focus

The focus of the research is on sustainably certified university student accommodations. A major argument for this choice is that sustainable student accommodations can be considered homogenous environments since these building blocks consist of living units of similar size, layout, interior design and equipment. Sustainability certifications such as LEED or BREEAM having become mainstream relatively recently, post 2000 (pg 10. BRE Global Ltd, 2014; Tufts, 2016), also means these buildings are likely to be all recently built along similar design programs in terms of sustainability goals. The population of student accommodations can also be considered fairly homogenous since the residents are students who are likely similar in terms of age - ranging from late teens to early twenties, and in similar life situation of moving to a new home, with a similar academic program-centred lifestyle. The aforementioned aspects reduce the number of potential confounding variables that other sustainable residential environments may hide, since the latter may show virtually limitless variations in terms of design, size, layouts and equipment, and may have residents of any age all with different lifestyles.

Additionally, there are convincing theoretical and empirical findings suggesting these building types, due to the life stage and life transitions of their inhabitants, have a high potential to promote sustainable behaviours. The occupants being in a stage of young adulthood have less ingrained habitual behaviours, are more open to learning new behaviours and are more interested in sustainability than individuals in other life stages (Arnett, 2015; Garabuau-

Moussaoui, 2009). Furthermore, university students also undergo residential relocation when moving into the accommodations which has been suggested to facilitate the uptake of new sustainable behaviours (Verplanken et al., 2008). Finally, students are in a stage when their identity undergoes significant changes (Arnett, 2015), identity which if integrates pro-environmental values may sustain pro-environmental behaviour for the duration of adulthood, with some resilience towards the disruptive effects of future relocations (Thomas, Poortinga, & Sautkina, 2016).

Moreover, student accommodations are in focus since these buildings have the potential to function as a teaching tool or learning laboratory for the adults of tomorrow. Sustainable student accommodations could be conceptualized as lived in visuals which communicate sustainable messages and guide sustainable attitudes and behaviours (Wu, 2016). Students residing in sustainable accommodations might adopt sustainable behaviours and sustainable ways to interact with the building and eventually take those behaviours with them when they move to their new homes. In this sense the behaviours learned in the sustainable student accommodations could have a spill over effect and therefore could be spread to other accommodations as well.

Finally, with purpose-built university accommodations currently housing about 600,000 students in the UK, and about 20,000 new bed spaces being developed each year to increasing standards (Cushman & Wakefield, 2017; TaylorWessing, 2018), ensuring new developments are well designed to enable and promote sustainable use is also a strong compelling argument for focusing on this building type.

These conditions together, suggest that enabling and promoting sustainable occupant behaviours by the architecture of sustainable student accommodations on the short and long term may be highly effective, and significantly advance efforts to mitigate climate change, hence placing this building type and its population in the focus of the present study.

1.4. Structure of the thesis

In the “Introduction” chapter, Chapter 1, the thesis provides background information for the study, along with the aim, objectives and focus of the thesis. With the “Literature review” from Chapter 2 the thesis details what is the state of knowledge on ways the architecture of sustainable buildings may shape environmentally significant occupant behaviours. To do so, it visits architectural philosophy, empirical findings from building sciences, theoretical and empirical findings from social sciences and design. The chapter concludes with the identified gaps in the literature and outlines the ensuing research questions to tackle those gaps. Chapter 3, overall

“Research Methodology” briefly presents the three empirical studies and illustrates how those studies together answer the research questions. The selected sustainable student accommodations and their characteristics are also briefly presented. Chapters 4, 5, and 6 present the three empirical studies: the “Occupant Interview Study”, the “Occupant Survey Study” and the “Architect Interview Study”. Each chapter - 4,5,6 - outlines the aim of the respective study followed by the methodology, the results and the conclusion. Chapter 7, the “Comparative Analysis and Synthesis” chapter, analyses the results of the three studies together in the following way. First occupant perspectives from the Occupant Interview Study and architect perspectives from the Architect Interview Study are compared on how the physical environment of sustainable accommodations affords environmentally sustainable occupant behaviours and building interactions. The findings are then weighed against the quantitative results of the Occupant Survey Study, allowing the identification of opportunities for architecture where it may better support occupant sustainable behaviours in the sustainable student accommodations. Finally, the “Discussion and Conclusion” chapter, Chapter 8 presents the key findings, followed by a discussion on how the research questions have been answered and how that contributes to the scientific knowledge, to methodology of future studies, as well as to architectural practice. This is followed by the identification of strengths and limitations of the study and by recommendations for future work. The thesis ends with concluding remarks.

2. Literature review

2.1. Introduction

This chapter will show based on the visited literature how architecture might have agency over many aspects of human life and may shape various behaviours. However, when it comes to sustainable occupant behaviours, there is limited literature on how architecture may support and promote sustainable occupant behaviour and occupant-building interactions. This is of major concern since in the universal efforts to curb climate change, architecture may be missing out on a significant leverage to reduce the environmental impact of buildings via well supported sustainable occupant behaviours. Even more so that the most sustainable buildings incorporating sustainable technologies were found to often fall short of expectations in terms of resource consumption partly due to occupant behaviour.

Given the lack of literature on how architecture might support sustainable occupant behaviour, this review integrates empirical studies from various fields, that may be telling of the relationship of the sustainable buildings and the sustainable behaviour of their occupants. In this context, empirical studies focusing on performance assessments of sustainable buildings will be visited together with studies that employ social science based perspectives of environmentally relevant behaviour in sustainable buildings.

However, the above-mentioned empirical studies provide contradictory results and therefore push the present review towards exploring those strategies developed by the discipline of design, akin to the discipline of architecture, that are concerned with understanding and shaping user behaviour. It is shown that while some of the behaviour-focused design strategies could be useful for architecture, these do not necessarily provide the answers the present thesis is looking for since design discipline is mainly concerned with artefact and artefact use rather than building and building use. Nevertheless, it provides this thesis with a valuable approach to better understanding user behaviour by relying on social science theories.

It will be shown how social sciences provide a rich knowledge base on environmentally significant occupant behaviours while highlighting theories that may inform design and architecture. Since design and architecture shape the physical, built environment, the section explores those theories applicable to environmentally significant behaviour that address the role of the physical environment in sustainable behaviour. The section highlights based on visited theories, that environmentally optimal or sub-optimal occupant behaviour may be seen as the result of a match or mismatch between designer intentions and understanding of future building use on one side,

and actual occupant experience and building use on the other, view that resonates with the design-specific concepts of Perceived Affordances. Finally, the lack of simultaneous empirical investigations of occupant experience and sustainable behaviour, and architect intentions to support or promote the same, calls into effect the present study.

2.2. Architecture, wellbeing and behaviour

Architecture from its very beginning offered us shelter and protection. However, architecture can and should go beyond its utilitarian function. As Zaha Hadid is generally attributed with saying: “Architecture is really about well-being. I think that people want to feel good in a space... On the one hand it’s about shelter, but it’s also about pleasure “. The neuroscientist Sarah Robinson and the architect Juhani Pallasmaa also suggest that “Buildings do not merely provide physical shelter... In addition to housing our fragile bodies and actions, they must also house our minds, memories, desires and dreams.” (Robinson & Pallasmaa, 2015). The philosopher Alain de Botton in his iconic book, “The Architecture of Happiness”, reiterates on the ideas of the 19th century art critique John Ruskin that architecture is expected to do two things: to shelter us and to speak to us, before suggesting that architecture has the potential and should communicate human values and beliefs which hold great significance but which often got forgotten. In the view of de Botton, architecture has the potential to suggest and to invite for certain ways of life, to suggest how life should be and to rebalance our often-unbalanced life. However, de Botton also argues that architecture “does not work as the law”, it cannot guarantee that the intended values, beliefs or ways of doings will be followed by its occupants. Instead it can be imagined as an invitation for certain ways of thinking, feeling and being, but it is eventually on its occupants whether those invitations and suggestion will be accepted or rejected (de Botton, 2006). The architect and design-theorist, Christopher Alexander, in his cornerstone book, “A Pattern Language”, shares a similar view on the potential of architecture to suggest and invite ways of living, to reconcile us with nature and to enhance life. Nevertheless, Alexander goes a step further and also suggests ways on how the previously mentioned beneficial qualities of architecture could be leveraged by town planners, architects and interior designers and provides a large collection of research-informed design patterns with the intention to be used as best guess and guidance while designing the built environment (Alexander et al., 1977).

2.2.1. Architectural determinism

Although the above architects, neuroscientist, philosophers and art critique emphasised the strong potential of architecture in shaping human thinking, feeling or even ways of doing, they also acknowledged its limitations and emphasized that architecture should be regarded as a

proposal or a suggestion rather than a deterministic medium, driving human mind and behaviour. On the other hand, the highly controversial and nowadays mostly discredited Theory of Architectural Determinism (Broady, 1966), which originally gained ground with the Modernist architectural movement, posits that the built environment is the sole determinant of behaviour and that behaviour is simply the outcome of the built environment. Simon Richards in his book “Architect knows best” (Richards, 2012) complicates the matter and differentiates between strong and weak determinism. While strong determinism refers to making judgment over how people live their lives and to forming behaviour through design decisions, weak determinism means using architecture more like a reminder of human values. Continuing the deterministic train of thoughts, Canter contrasted the active and passive role of the designer, active being the belief that the designer can directly influence behaviour while passive is to be thoughtful about the way people interact with the space (Canter, 1974). While the strong, active, more prescriptive concepts of architectural determinism received wide criticism for their authoritarian nature (Broady, 1966), the weak and passive approach, its gentler concepts are more widely accepted and resonate with the stance of previously mentioned architects and thinkers, such as Christopher Alexander or Alain de Botton, according to whom architecture has mind and behaviour shaping qualities and potentials, but those potentials are limited, leaving the final decision-making and choice to the occupant themselves.

2.2.2. Philosophy and theory in the context of sustainability

Putting these ideas in the context of the present work, the stance of the thesis is that although architecture via the sustainable accommodations cannot force occupants to act more sustainably and live a more sustainable lifestyle, it may certainly invite and guide occupants to act and use the space in a more sustainable, environmentally more protective and less resource intensive way. While enhancing human life and experience by leveraging architecture is vastly present in the works of previously mentioned authors, sustainability, a pressing issue of our time if not of all times, remains unexplored in their works. When Alain de Botton was directly posed with the question whether and how sustainability and sustainable behaviours are supported by the real-life architectural projects he was involved with, and how the architecture of those projects promote sustainable values, de Botton revealed that sustainability and sustainable behaviour is considered to be an integral part of design via sustainability certificates and innovative and resource efficient features integrated in the building. The fact that when it comes to sustainability de Botton refers to certificates and efficient technologies incorporated in a building is somewhat surprising considering the value-reminding, behaviour-inviting and life-rebalancing philosophy of architecture put forward in his work. Isn't it true that protecting the environment and reducing

our environmental impact is also some sort of moral value we often forget about in our daily life and would need to be reminded of by architecture, especially considering the pressing issue of unprecedented environmental degradation and the imminent threat of climate change? Isn't it true that we would need architecture to suggest and invite us for more sustainable, environmentally more protective ways of living our life in order to reduce our environmental impact and mitigate climate change? And finally, isn't it true that our life cannot be balanced and enhanced if the natural environment is degraded and climate change is left unmitigated? My firm belief is that the answer for the above questions is yes. We need architecture, more than ever, to remind us and to support us in acting more sustainably and using our physical, built environment in a more environmentally protective, less resource intensive way could be a significant step on this journey.

Christopher Alexander also emphasises the eminent role architecture has in enhancing our life. Nevertheless, he steps beyond philosophy and proposes 253 architectural patterns to achieve that, often relying on elements of nature, such as access to nature, or ensuring sufficient amount of daylight and indoor sunlight (Alexander et al., 1977). He even goes further and applies some of the proposed patterns in a real-life university campus development project, described extensively in his book (Alexander et al., 2012). While enhancing future occupant life by harnessing the benefits of nature is a major goal of the project, he also puts forward the idea that the design and construction of the building should happen in a manner protective and considerate of the natural environment, respecting the land, considering the climate and connecting with the local flora and fauna. However, neither the proposed life enhancing patterns, nor the environmental protective design and construction approach touches on supporting environmentally protective occupant behaviour. This omission is of major concern since occupant behaviour may have a significant detrimental impact on the natural environment which if degraded may lose its capacity to enhance or support human life. Therefore, the thesis argues that architects may not only need patterns for enhancing occupant life via natural elements but also patterns that protects the natural environment by promoting sustainable occupant behaviours and lifestyles.

2.2.3. Architectural science and sustainable behaviour

While reviewing architectural literature on how architecture may promote sustainable occupant behaviour two characteristics become apparent. On one side, literature is relatively rich in studies investigating the how architecture may shape various aspects of human life and behaviour. On the other side there is a scarcity of research on how sustainable architecture may shape sustainable behaviour. The following sections elaborate this contrast.

Architectural influences on various aspects of human life

First, the literature showcases a plethora of ways architecture is attributed with shaping perception, cognition, emotions and behaviour (Augustin et al., 2009; Goldhagen, 2017; Kleedwell, 2017; Kopec, 2012; Sussman & Hollander, 2015). It does this in an increasingly sophisticated manner while touching upon most aspects of human life from safety and security (Crowe, 2000; Kuo & Sullivan, 2001; Newman, 1973), through physical and psychological well-being, health and healing (Sternberg, 2009; Ulrich, 1984), to academic and professional performance (Augustin et al., 2009; Kopec, 2012) including a variety of built environment typologies starting from the home environment to education facilities and workplaces (Kleedwell, 2017), from healthcare facilities (Sternberg, 2009) to retail and entertainment amenities (Augustin et al., 2009), while expanding in scale as far as the urban environment (Lynch, 1960; Whyte, 1980, Alexander et al., 1977; Gehl, 2009; Jacobs, 1961). As such, the literature provides a substantial body of evidence on how office design might enhance professional performance, how the physical characteristics of educational facilities might affect academic performance, how the design of healthcare facilities can promote healing, reduce patients recovery time and the occurrence of medical errors, or that well design urban environments can lead to increased personal satisfaction, can generate socially more desirable and responsible behaviour and even boost the economy of the street.

An impressive amount of research seems to be available on ways architecture may enhance human life in hospital design and its power to facilitate healing, shorten hospital stays and reduce medical errors with studies looking at the relationship of window views of nature and patient recovery time and use of painkillers (Ulrich, 1984), of sunny rooms and amount of pain medication needed by patients recovering from surgery and their release time from hospital (Augustin et al., 2009), of noise level with patient stress levels and recovery time (Sternberg, 2009) and number of staff errors (Augustin et al., 2009), of neonatal unit layouts allowing mother – baby coupling and length of stay for premature babies, rates of illness and needed ventilation assistance (Keedwell, 2017), or difficulty of wayfinding and patient stress and staff time spent directing visitors and patients (Augustin et al., 2009; Keedwell, 2017) to name but a few. While these studies offer promising pointers to architects, questions may still arise regarding the quality of predictors and how these incorporated together in design may impact human life in healthcare facilities. For instance it is still unclear what qualities the views of nature should have to help recovery and how exactly windows helped recovery, whether it is the light, air flow, sound or smell of nature, or the rhythms of day and night (Sternberg, 2009; Ulrich, 1984), or how the

combination of visual, auditive, thermal, air quality or tactile environment may relate to patient recovery or to medical staff performance.

The literature is also abundant in investigations of the relationship of office design and professional performance, suggesting that the layout of the space and its organisation in cubicles, open plans or private offices may relate to privacy and performance; that noises and noise levels of various degrees may relate to staff stress, distraction, irritation and productivity; that personalisation and control over the physical environment may relate to performance and engagement; that quality of indoor environmental qualities such as lighting, temperature or air quality and/or occupant control over these may relate to productivity; that light colour and interior colour schemes may facilitate relaxation or alertness to various degrees; or that vegetation in offices may relate to working memory to mention just a narrow subset of knowledge available to office architects and interior designers (Augustin et al., 2009; Keedwell, 2017; Kopec, 2012). This might be reflected by case studies of informed office designs where companies moving into the well-designed offices found a significant improvement in key measures such as job control, collaboration, and time and cost of business processes (O'Neill, 2007 in Hamilton & Watkis, 2009).

For educational facilities, it is generally accepted that noise levels, lighting quality, indoor air quality and thermal comfort may be related to student performance; and was also found that in schools with ventilations systems using non-recycled air student working memory seemed improved as compared to that of students from recycled air ventilation schools (Bakó-Biró et al., 2012 in Keedwell, 2017); that visually cluttered environments may be distracting for student (Barrett et al., 2015), that views of the exterior and natural light may facilitate students learning but may also distract them when the outside is animated or when natural light causes glare (Hamilton & Watkins, 2009). It was also found that moderate classroom density of 2.8-3.7 sqm/student may be ideal for learning (Gifford, 2011). Others report that students learn better, have better test results and teachers take fewer sick days off in green schools (Kats, 2006 in Augustin et al., 2009) however it is not investigated how green buildings achieve this outcome. Recent large sample based studies report that in British primary schools learning progress is significantly related to the physical characteristics of the classroom such as light, temperature and air quality, but also to individualisation measures and stimulation measures incorporating complexity and colour, all accounting for 16% in variation in overall progress over a year, and that the overall school characteristics outside the classroom may be of lesser importance (Barrett et al., 2015). However, despite the multitude of school environment studies that may inform school

architects, connoisseurs of the research field tend to agree that conclusions are equivocal and that there is no systematic evidence-based guidance available for good school design (Davies et al., 2013; Hamilton & Watkins, 2009).

At urban design scale, available knowledge encompasses multiple aspects of how the design elements of a city relate to human well-being, street use, social interactions, or even crime levels. When looking at the street as an urban design element, it is generally accepted that a conglomerate of design features such as the width and length, the visibility and density it allows, its cleanliness and human scale, the complexity, variability and aesthetics of buildings, the ground floor design of the buildings as seen by pedestrians and occupants alike, and the layout favouring cars, bicycles or pedestrians, likely relate to how people use the street, how fast they walk, whether they spend time on the street, interact with each other and use it as a meeting place or not (Gehl, 2009; Keedwell, 2017; Sussman & Hollander, 2015). Although it is not clear to what extent these components individually or together predict ways of using the streets, many of the findings feel instinctively valid and are enforced by successful cases of city transformations into more walkable and liveable environments (Gehl, 2009).

The square, another central topic of urban design, and its design characteristics are also accepted to relate to ways people use the square. William H. Whyte (1980) observes that people on small squares of New York tend to avoid shadows and stand on the sunny areas, while also being attracted to water features and facilities offering refreshments, and prefer mobile urban furniture instead of fixed. Gehl (2009) defines 12 quality criteria a square design should adhere to in order to attract visitors and accommodate or even generate a wide range of activities such as walking, sitting, talking, or self-expression. As a rule of thumb, it is also proposed that squares should not exceed 100 x 100 m in size in order to allow visitors good overview and stay within what visual senses can still encompass. Additionally, the design of squares and positioning of amenities on the square may also consider people's evolutionary tendency to protect their backs and explore the square along the edges – phenomenon potentially explained by 'thigmotaxis' (Sussman & Hollander, 2015); and rest or sit along the edges of a square.

While streets, squares and buildings also appear in Kevin Lynch's work as instances for 'paths', 'node's, and 'edges' respectively, he adds two more elements indispensable in his view for promoting successful wayfinding in the city (Lynch, 1960). One of these elements are 'landmarks' which are defined as easily identifiable physical features offering a point of reference for city-dwellers or visitors. The other is the 'district' which is described as a relatively sizeable part of the city, with authentic and distinguishable characteristics. At the neighbourhood scale, it is

suggested that residents have a preference for *easy* to follow grid structures which are perceived more walkable and generate more walking behaviour (Gallimore et al, 2011).

At the city scale, it is suggested that well-designed and compact cities may sway the choice of residence towards city centres and divert from choosing suburbs as home, likely decreasing car use and prompting more walking behaviour (Keedwell, 2017). While the 'compact city' may seem rather fluid, it can be thought of as a city where residents can reach any service and amenity they might need for mundane life within a reasonable time, i.e. ten minutes, by foot, which is commonly referred to as 'walkshed' life in city planning.

Finally, safety and security concerns in urban environments have also generated ample research resulting in seminal works like Newman's 'Defensible Space: Crime prevention through urban design' (1973), where it is discussed how design features allocated to conceptual groups of Territoriality (gates, walls, hedges, fences), Surveillance (street lighting, windows and doors, public benches, playgrounds, lack of spaces that allow concealment) and Symbolic barriers (personal objects, picnic tables) in the urban environment may be employed to reduce or deter criminal behaviour such as burglary. Latter empirical research questioned but eventually confirmed most of the criminal behaviour reducing design concepts laid down by Newman (Brown & Altman, 1983; Poyner, 1983).

Architectural influence on sustainable behaviour

The second major finding of the review of research available on the relationship of architecture and occupant well-being and behaviour is that there is surprisingly little literature on purposefully supporting and promoting sustainable occupant behaviour by architectural design. Even when focusing on the architecture of sustainable buildings, which are meant and claim to serve sustainability at the highest possible level, occupants' environmentally sustainable behaviours and how that could be supported by architectural design is largely unexplored and neglected in the literature.

The fact that this area is so overlooked is equally surprising and of concern for several reasons. One is that occupant behaviour has been found to be a substantial part of building overall resource consumption and if not known how to adequately support it by design, it could lead to lower than expected building performance (Delzendeh et al. 2017). This in turn may negatively affect the reputation of sustainable buildings by not meeting expectations while also puts a toll on architect's reputation and questions their credibility in delivering the expected results. However, the fundamental damage the unsupported sustainable occupant behaviours and unsustainable

building use can cause is the excessive, sometimes profligate use of environmental resources, such as energy and water, but also other types of environmental impact, such as disproportionately high refuse waste and low recycling to name but a few.

Considering the universal battle for mitigating climate change by reducing the environmental impact and by moderating resource consumption, and the important role architecture, especially sustainable architecture plays in that, the question arises: if the architecture of sustainable buildings cannot rise to the challenge to moderate resource consumption and to reduce the environmental impact, how can that be expected from the design of more conventional buildings? Knowing that buildings contribute to almost half of overall CO₂ emission and 40% of resource consumption (GABC, 2018) further enforces the conviction that architecture, especially of sustainable buildings, should own the responsibility to reduce environmental impact and play its part in mitigating climate change.

Architecture and architects already aim to support sustainability by relying on sustainable elements such as low carbon materials, sustainable technologies, and sustainable strategies such as site selection, building orientation, sustainable transportation of the construction materials, sustainable construction methods and sustainable building decommissioning and material reuse strategies. Nevertheless, often sustainable buildings are only sustainable in terms of design and technology while the way the building, its integrated features and technologies are used after design and construction are completed, equally important to ensure the sustainable functioning of the building and the expected building performance, is not well supported.

The reason behind the lack of support or adequate support for sustainable behaviour could be that while the technological solutions are widely present in the literature architects can use during design, sustainable occupant behaviour is less so and therefore may be considered in a more implicit manner during design. The architect may make assumptions on occupant behaviours or may use predictive models that forecast energy use of the building based on predefined patterns, but rarely have literature aiding design in supporting sustainable occupant behaviour. Hence, it would be unreasonable to expect the field of architecture and architects to excel at mastering the nature of environmentally significant behaviour and ways to support it by the design of sustainable buildings without the appropriate knowledge sources.

This makes even more sense when considering the significantly accruing knowledge architecture can rely on in other topics such as promoting healing by the design of healthcare facilities, increasing productivity and performance via design of the office buildings, or facilitating learning

and student well-being in educational buildings. In these fields, architects might rely on the evidence-based rules of thumb (Hamilton & Watkins, 2009; Nussbaumer, 2009) such as providing a window with a view to nature could promote healing and reduce length of hospital stay (Ulrich, 1984), or that high ceilings might promote creative thinking while low ceilings might be more beneficial for focused and analytical thinking also called cathedral effect (Lidwell et al., 2010; Meyers-Levy & Zhu, 2007), or that efficient noise insulation may help students concentrate and moderate fatigue (Persinger et al., 1999; Ronsse & Wang, 2010; Turunen et al., 2014). Nevertheless, when it comes to how sustainable behaviours could be promoted by the architectural design of sustainable buildings, the literature is scarce. Thus, architecture and architects, even if they wish to promote more sustainable occupant behaviours have no adequate knowledge base they could access.

As a first step to fill that gap, this review will explore current knowledge of how the sustainable buildings, as the outcome, the end product of sustainable architecture measures up to the challenge of hosting sustainable occupant behaviour. As such, it will investigate empirical literature from Building sciences and Social sciences concerned with sustainable behaviour in the context of sustainable buildings.

2.3. Sustainable buildings and occupant behaviour

Sustainable buildings have, in theoretical terms, countless benefits and may have the potential to generate positive impact on the environment and on human life. Nevertheless, occupant behaviour and the way it is used plays a crucial role in whether the buildings designed with sustainability in mind will deliver the expected sustainability outcomes and meet their intended objectives (Day & Gunderson, 2015; Zuo & Zhao, 2014). Even the most technologically sustainable buildings may generate less than optimal environmental and energy performance outcomes (Asmar & Tilton, 2015) and may have a detrimental impact on inhabitants' health, performance or comfort if used in an inappropriate and unintended way. For instance, a heating system may be used in a way that overheats a space, leading to energy overuse, occupant thermal discomfort and diminished work performance (Lan et al., 2011) and related to increased breathlessness (Chatzidiakou et al., 2013). Therefore, as Day and Gunderson put it when referring to Brown: "passive design strategies require active occupant engagement" (Day & Gunderson, 2015), meaning that occupants need to operate the systems effectively in order for the systems to function efficiently. That is, besides technical and material sustainability, the buildings also need to deliver behavioural sustainability (Williams & Dair, 2007) to achieve a truly sustainable state.

In building science, a considerable research focus is allocated to the study of the building performance gap (Asmar & Tilton, 2015; Leaman & Bordass, 2001), defined as the difference between designed and actual resource use, which in the case of sustainable buildings was found to occasionally result in 400% higher CO₂ emissions than predicted (Gupta & Gregg, 2016). The field considers that occupant actions often play a substantial part in the performance gap (O'Brien & Gunay, 2014) and attribute 10%-80% of the gap to it (van Dronkelaar et al., 2016). Kathryn B. Janda, in her paper "Buildings don't use energy: people do" (Janda, 2011) also argues that occupant behaviour is a key component of building energy use and suggests that between 50% to 25% of difference in use can be attributed to occupants behaviour rather than technical characteristics of the residences while difference in use may present large variations up to 300%. This is in line with other studies concluding that "energy-efficiency behaviours account 51%, 37%, and 11% of the variance in heat, electricity, and water consumption, respectively, between dwellings" (Gill et al., 2010). Finally, there are also studies that go as far as suggesting that behaviour and lifestyle is more important in achieving the intended, sustainable building performance outcomes than the sustainable technology integrated in the building (Pilkington et al., 2011).

While the discipline heavily researches the impact of occupant behaviours on sustainable building energy performance, the reverse of this relationship, namely how and in what ways the sustainable buildings might shape environmentally relevant behaviour has received scant attention (Azizi & Wilkinson, 2015; Wu, 2016 p.3-9). However filling the knowledge gap is becoming pressing (Wu et al., 2017) especially since it is theorised that occupants often interact with their built environment to establish or to restore their comfort and the external factors, such as the building and its features, might have an influence on how those interactions occur (O'Brien & Gunay, 2014). Comprehensive reviews further speculate that occupant behaviour may be influenced in various ways by the architecture of the building and its interior characteristics. For instance Wu et al. (2017) suggest that sustainable buildings may act as communication channels of sustainability, while Delzendeh et al. (2017) propose the aesthetics, the composition of the interior space, circulation or even colours or materials may sway sustainable behaviour. Finally, O'Brien and Gunay (2014) conclude that the availability, accessibility, and complexity of the building systems may be telling of how occupants adapt to their environments or adapt the environment to themselves in an effort to achieve their comfort. Nevertheless, the potential effect sustainable buildings may have on occupants' energy attitudes and behaviours is largely unexplored and empirically undocumented (Delzendeh et al., 2017).

There are a handful of empirical studies that investigate whether sustainable buildings support sustainable behaviours. However, the conclusion of these studies is equivocal due to contradictory results: some findings suggest that sustainable buildings are in fact conducive of sustainable occupant behaviours and practices, while other findings suggest that sustainable buildings do not necessarily lead to more environmentally and energy friendly ways of doing, as detailed in the upcoming sections.

2.3.1. Sustainable buildings as settings of sustainable behaviours

On one side, it is suggested that sustainably designed buildings facilitate sustainable occupant behaviours and that occupants in these environments adopt and exhibit more sustainable behaviours and practices compared with occupants of more conventional buildings. Wu et al. (2013) investigated whether simply being in a sustainably designed building elicits more sustainable occupant behaviours. The observational study compared waste separation habits in a sustainably designed university research centre and a conventional university student union building, both having similar waste management facilities. The results revealed that occupants of sustainable buildings were significantly more likely to exhibit better, more correct waste separation practices than occupants of the more conventional building. Furthermore, the study found that the occupants of the sustainable building rated themselves higher on environmental consciousness than the occupants from the conventional building. The researchers explained their finding with the theory of Embodied Cognition (Wilson, 2002), which postulates that cognition is situated and therefore perception and behaviour are shaped by the real-world context, therefore being in a sustainable building elicits sustainable feelings and actions (Wu et al., 2013). Although Wu and colleagues supported their hypothesis that context, in this case the sustainable building, elicits environmentally supportive feelings and behaviours, the researchers acknowledged that the exact features of the building facilitating the sustainable behaviour remained unexplored.

Similarly, Clarke in his doctoral thesis also suggests that sustainable buildings do promote sustainable attitudes and behaviours (Clarke, 2013). The results of the observations, interviews and surveys performed in five case studies each focusing on a sustainable building, revealed that buildings with high sustainability commitment may act as incubators and learning environments for adopting environmentally sustainable attitudes and behaviours. Although Clarke, similarly to Wu et al. (2013), argued that sustainable buildings are supportive of sustainable attitudes and behaviours, the components or features of the physical environment that contribute to those behaviours and the mechanism how this contribution comes into effect, remained unexplored.

Khashe et al. (2015) looked at how awareness about the sustainability profile of a building might shape artificial light use and recycling. Their experimental study was performed via immersive virtual environments with university students randomly assigned to an experimental group - aware of the high sustainability of the building, and a control group - unaware of the sustainability profile of the building. Participants were asked to execute certain tasks involving light use and recycling. The study found that participants from the experimental group showed more environmentally friendly light use and recycling behaviours when compared to participants from the control group. Therefore, it was suggested that awareness on the sustainability branding of the building might promote more sustainable light use and recycling practices. Furthermore, a follow-up questionnaire examined whether demographic variables, together with environmental knowledge, values or attitudes might influence participants' choices on light use and recycling behaviours. The results revealed no link between participants' demographic characteristics, such as age, gender or education and pro-environmental behaviour. Nevertheless, environmental values and views were found to have had significant effect on the influence of LEED branding on occupants' choices regarding light use and recycling. Although the experiment supported that knowledge on the sustainability profile of the building promotes more sustainable behaviours, the fact that the study was conducted in a virtual environment and not in a real-world context adds to its limitations and identifies the need for further research on this highly relevant topic in a real-world environment.

Berry et al. (2014) shows that home owners moving to sustainable, zero energy homes think their heating behaviour has been positively influenced by the sustainable building and its systems and their thermal comfort has been significantly improved. Furthermore, measurement data of thermal comfort energy use confirmed the sustainable homes used less energy than nearby more conventional housing developments, supporting the self-reported positive shift on behaviour. Although the study suggests that moving into a sustainable home promotes sustainable heating practices, which and how the elements of the building led occupants to uptake more sustainable behaviours remains unexplored in this study. Additionally, it was also not made clear in the study whether the lower energy consumption could be attributed solely to positive occupant behaviours or to technological components as well.

Williams et al. (2010) also found based on a survey performed with occupants of 13 UK-based mainly residential sustainable buildings, that home based energy and water use behaviours were significantly more sustainable than the national UK average according to DEFRA survey, and concluded that sustainable neighbourhood-scale developments may be positively influencing

environmentally significant occupant behaviours and practices. What is unique about this study compared to the previously mentioned empirical investigations is that Williams and her colleagues are more explicit and provide more granular data on which feature of the built environment is related to which behaviour. For instance, significant relationships were found between energy use and controllable, energy efficient heating systems as well as accessible windows allowing passive ventilation, while greywater and rainwater recycling systems and dual flush toilets were found to be significantly associated with using less water in the homes.

2.3.2. Occupant behaviour independent of building sustainability

In opposition to the earlier presented empirical studies there are some research findings suggesting that sustainable buildings do not necessarily result in sustainable occupant attitudes and behaviours.

Williams and her team in the previously mentioned study where they found positive energy and water use behaviours in sustainable homes, also show that the same occupants report poorer recycling, composting and travel mode choice behaviours than the UK national average, despite available recycling facilities and pedestrian-friendly routes to reach public transport. Their findings suggest that while the built environment might have the potential to support certain environmentally relevant behaviours, other environmentally relevant behaviours might fall out from its range of influence (Williams et al., 2010). However, the results may also be interpreted as an indication that while some features of the sustainable built environment were designed in a way that supported sustainable use, other features and their design, such as recycling facilities, were less supportive of recycling practices.

Further studies relying on self-reported data also suggest that the sustainability of a building does not necessarily lead to increased occupant motivation to act sustainably (Azizi & Wilkinson, 2015; Kato et al., 2010). However, identical occupant motivation levels between sustainable and more conventional buildings do not necessarily mean similarly sustainable occupant behaviours. Kato et al. shows in the same report that despite occupants not feeling more motivated to be sustainable by the sustainable building certain energy saving practices, such as turning off computers after work, waste separation for recycling, or aiming to reduce paper use were highly prevalent in the surveyed sustainable environments. Azizi and colleagues also highlights that despite similar motivation levels, occupants of sustainable houses acted more sustainably than occupants of conventional buildings (Azizi & Wilkinson, 2015).

Pilkington et al. (2011) also provides evidence that permaculturists (defined by the paper as individuals willingly adopting and maintaining highly sustainable lifestyles) living in various, more conventional building types had on average 1.6 times lower personal ecological footprint (PEF), than residents of eco-friendly, energy efficient homes. Their findings suggest that sustainable buildings do not necessarily generate more sustainable behaviours than their more conventional counterparts and that ultimately occupants' knowledge and information on sustainability, their motivation to act sustainably and their lifestyle choices and behaviours might have a bigger, more sizeable impact on the building energy and environmental outcomes than the building technology itself. The study although supports the notion that sustainable buildings are not a prerequisite or a condition of sustainable behaviours, it falls short in individually controlling for the effects of variables such as lifestyle of the participant or sustainability of their residence. It would be interesting to see how two groups very similar in terms of environmental aspiration would liken when compared along sustainable buildings residency versus more conventional building residency. It could be that if the occupants are similar in lifestyles, the occupants of sustainable building would generate lower PEF's than those of more conventional buildings.

2.3.3. Conclusion

The previously presented scarce studies exploring whether sustainable buildings promote sustainable occupant behaviours may not allow building a valid conclusion for a number of reasons.

First, the above-presented studies reach opposing conclusions as obviated by their grouping in the two preceding sections. Furthermore, even the studies that have a decisively positive conclusion and suggest that sustainable building may foster or promote sustainable occupant behaviour fall short in explaining in what ways sustainable buildings may be conducive of sustainable occupant behaviour, which is a central concern for the present thesis.

Additionally, in the first group of studies, the Wu (2013) study and the Clarke (2013) thesis may be biased towards looking at participants who already act sustainably out of conviction, and irrelevant of sustainability of the building. This bias can be assumed since the studied buildings - Centre for Interactive Research on Sustainability (Wu et al., 2013), eco-centres and institutes for sustainable education (Clarke, 2013), host strongly sustainability oriented activities, making it reasonable to suspect that visitors and staff may already be strongly committed to sustainability and are acting in line with that commitment, making it questionable whether and how the building itself is helping sustainable behaviour.

A similar lack of control for sustainable commitment of occupants can also be found in the opposing voice of the Pilkington (2011) study, where participants with comparable environmental commitment are not distributed between sustainable and conventional buildings in order to assess the effect of the building's sustainability on occupant PEF. Hence Pilkington's suggestion that sustainable buildings don't necessarily foster sustainable occupant behaviour is also debatable.

Finally, the studies suggesting that sustainable buildings may promote sustainable behaviour do not specify what exactly in the building facilitates sustainable behaviour. Although some studies mention situational characteristics like 'being in the building' (virtually) (Wu, 2013), or knowing about the sustainability certificate of the building (Khashe et al., 2015) as potentially facilitating sustainable occupant behaviour, these aspects do not include the specific physical characteristics of the building that may be promoting the sustainable behaviour.

One exception is the research carried out by Williams and colleagues (2010), where significant relationships were found between the presence of certain physical features of the sustainable buildings and specific environmentally relevant behaviours. This is encouraging in the exploration on the potential of sustainable buildings as a promotor of sustainable occupant behaviours. However, the very same study also concluded that not all features could be connected to the respective environmentally significant behaviours, since the relationship between some pairs of features and behaviours was statistically insignificant. This raises the key question of how and why the sustainable features correlated with sustainable occupant behaviour were potentially able to support more sustainable behaviour.

However, the key idea of the Williams et al. (2010) study, to pair up specific physical design features of sustainable buildings with specific sustainable behaviours it assumes those features may relate to, is worth further exploration. The approach of pairing up physical features with specific user behaviours is very similar to that inherent to design, where a major concern is how the artefacts, products, services or the built environment will be used, thus how the behaviour of the user interacting with the design outcome will unfold. Furthermore, design may also have a more persuasive goal and ask itself how a specific way of using an artefact is achievable. This same question, if explored in the context of reaching sustainable building use, might provide partial answers to the present exploration as presented in the following section.

2.4. Design and sustainable behaviour

Design for Behaviour Change, abbreviated DfBC hereafter, is a field of design research which employs a philosophy akin to Architectural Determinism and advocates that the intentional application of adequate design strategies may predefine, support or change user behaviour and interactions with products and services for the better in areas such as sustainability, health, safety or pro-social behaviour (Niedderer et al., 2014). However, unlike the mainly philosophical approach of Architectural Determinism, DfBC relies heavily on theories and empirical and experimental findings from social and behaviour sciences in combination with design research to identify methods designers can consider and use as guidance to shape user behaviour. The strategies and approaches encompassed by DfBC can be grouped in two major categories that are similar to the gentler and the stronger views of Architectural Determinism: voluntary approaches provide information and feedback to motivate the user to want to do or not an action without imposing an action; and prescriptive approaches also called context driven approaches, which by the built environment makes the target behaviour easy or difficult for the user, enabling or restricting use as such (Niedderer et al., 2014). Researchers of DfBC argue that the more complex and challenging an issue, the more voluntary methods become unreliable and may require solutions that rely on context to either enable or constrain certain behaviours (Niedderer et al., 2014). Healthcare and crime prevention for instance are areas where context driven approaches have been successfully adopted in design and respectively architectural design to reduce medical errors and crime rates (Grout, 2006 and Crowe, 2000 in Niedderer et al., 2014). Another area outlined as complex and challenging that accommodates application of DfBC strategies, is Sustainability via Design for Sustainable Behaviour, abbreviated DfSB hereafter (Boks et al., 2015; Lockton, 2013; Niedderer et al., 2014; Tang & Bhamra, 2008; Wever et al., 2008).

DfSB positions the principles and strategies for promoting sustainable behaviour along an axis of user degree of control, from leaving users full control by simply informing them or providing them feedback; through providing moderate control to the user via persuasion and seduction and finally providing little or no control to the user by determining or even forcing desired ways of use (Lockton, 2013; Zachrisson & Boks, 2010). Informing strategies may be exemplified by poster or slogan designs aimed at informing the user and raising awareness on less resource intensive use, the power aware cord which provides feedback to the user on electricity use via its luminance (www.inhabitat.com), or the energy meters allowing occupants to see and follow their consumption. A more persuasive approach may be exemplified by the dual-flush of bathroom facilities where the less water intensive option is more apparent and easy to use, the Aware Puzzle Switch (www.loove.org) - a light switch designed to leverage people's tendency to prefer

order and compel them to readjust the switch when it is ON and looks disordered to OFF to regain order, or the recycling facilities where the openings have specific shapes to guide and suggest recycling. Finally, good examples for methods with lower degree of user control, that is more deterministic approaches could be the automated heating and cooling facilities of “Aircon off” (www.airconoff.com.au) which independently from users’ wants and wishes turns heating and cooling off when a room is vacated for a given period of time.

As the previously enumerated design approaches and their application suggests, DfSB gathers sustainable use-supportive design approaches mainly applied for product design. A number of the above applications of DfSB might be promising for architecture since these objects can be integrated in buildings that aim to promote sustainable occupant behaviour. However, the focus seems to be on individual objects used independently from other artefacts or systems where one specific user behaviour is being pursued. As such, it does not provide understanding on the concerted effect multiple design features coexisting within a sustainable building might have on sustainability of occupant behaviour. Furthermore, since it is mainly focused on individual objects and artefacts, it also lacks discussing how architectural features such as orientation, light and light levels, floor level, floor layout, thermal environment, and so many others may be related to sustainable occupant behaviour.

Nevertheless, DfBC and DfSB demonstrates remarkably well that a theoretically and empirically founded understanding of specific user behaviours and its integration into the design of objects, artefacts and environments may generate environmentally and socially beneficial behavioural outcomes. Following that line of reasoning, the contention of this study is that a theoretically and empirically founded understanding of sustainable occupant behaviour is required for comprehending how the architecture of sustainable buildings may shape sustainable occupant behaviour. Therefore, the next section will explore social science theories and empirical findings concerned with environmentally significant behaviour in the context of the built environment.

2.5. Environmentally Significant Behaviours

Environmentally significant behaviours, hereafter abbreviated ESB, in student accommodations don’t have a dedicated literature as such. However, university student accommodations show similarities with the home environment in the sense that they provide living quarters and home-like environments for students. In fact, for the period of their stay, the accommodations become the residence of the students, where most of the ESB performed are similar to those performed in the domestic environment. Therefore, the present review builds on the literature of domestic ESB for understanding occupant ESB in student accommodations.

Environmentally significant behaviours are defined as all the behaviours that have a direct or indirect impact on the environment, independent of whether that impact is beneficial or detrimental. One of the most commonly used categorisation divides household related ESB as either efficiency or curtailment behaviours (Stern, 2011). While efficiency is a one-shot behaviour that may imply purchasing and adopting new, energy efficient equipment, curtailment behaviours are repetitive and mainly represent the way the equipment, products or systems are used and is often associated with a significant decrease in comfort and quality of life. Besides being considered more comfortable, earlier studies indicate that purchasing energy efficient products can yield better results in terms of reduced environmental impact than making efforts to use pre-existing products and systems in a more environmental considerate way (Gardner & Stern, 2008). Student accommodations with high energy efficiency certificates, by their very definition and function, already accommodate new, energy efficient features, thus catering for the “efficiency” of occupant ESB.

On the other hand, it has been shown that the sheer purchase and integration of energy efficient and environmentally considerate appliances does not necessarily result in the expected energy reduction (Abrahamse et al., 2005). Stern, the advocate of “efficiency”, also acknowledges that “efficiency” can be weakened by behaviour patterns such as the “rebound” effect (Druckman et al., 2010), therefore understanding “use” (i.e. curtailment) is pivotal for reducing the environmental impact of domestic behaviours. Even more so that empirical studies performed in student accommodations also found that sustainable accommodations may have similar resource use intensity as their more conventional counterparts (Asmar & Tilton, 2015).

To understand how occupants interact with the sustainable accommodation and use its features, first an exploration of the literature is required, focusing on what shapes residential ESB. Social sciences have a wide range of theories and models that explain behaviour, including environmentally relevant “use” behaviour. These models resort to defining a variety of factors that may sway behaviour, some of which are seen as more internal to an individual, such as knowledge, attitude or motivation, while other factors are more contextual and external to an individual, such as the physical, social, economic or politic environment (Clark, 2010; Jackson, 2005; Niedderer et al., 2014). In sustainable student accommodations, individual factors could be conceptualized as knowledge about sustainability and the sustainable character of the building, attitude towards sustainable lifestyles or motivation to use the building in a sustainable way. The contextual factors could be the sustainable physical environment enabling or limiting sustainable use, or the social environment i.e. other residents and their behaviour.

Since the thesis relies on the informing power of the most established theories and models of behaviour, the following sections details those that have been successfully adapted to and adopted in understanding environmentally significant behaviour.

2.5.1. Generic psychological models

The exploration of what drives behaviour, from the very outset of social science as a field of study, generated theories according to which personal behaviour was the results of individual and contextual factors. Kurt Lewin, regarded as a founder of social psychology, in his equation $B = f(P, E)$ famously proclaimed that Behaviour(B) is a function of the Person(P) in their Environment(E), where the Environment incorporates both the physical and social context (Lewin, 1935). Similarly, Herbert Simon conceptualizes “behavioural scissors” (Simon, 1990) suggesting that behaviour is driven by both cognition and context and coins the concept of “bounded rationality” postulating the decision-making is limited by the manageability or complexity of a problem, cognitive limitations of the individual and the time available to make a decision (Simon, 1957). These early behavioural theories have laid the foundation of many theories to come used in investigating environmentally significant behaviour, such as the Attitude – Behaviour – Context (ABC) model.

2.5.1.1. *Attitude – Behaviour – Context (ABC) model*

Developed by Stern and his colleagues specifically for understanding environmentally significant behaviour, the ABC model, similarly to Lewin’s Field Theory, suggests that ESB is an outcome of both internal or attitudinal variables and external or contextual variables. Attitudes consist of qualities internal to the individual such as values, beliefs or norms, while external factors include physical, social, financial constraints or even policy support. In addition to the early theories of behaviour mentioned above, the ABC model also suggests that the strength of one factor might have an impact on the effect of the other factor on behaviour. More specifically, when contextual factors are very strong, attitudinal factors fade away in predicting behaviour and when contextual factors are neutral, attitudinal factors become strong predictors of behaviour (Stern, 2000).

The ABC model proposed in the context of waste management behaviours such as recycling or reuse has been adopted later on and found to have good explanatory power for the same behaviours according to subsequent empirical studies as well (Olander & Thøgersen, 2006). The area of application (recycling) and the inclusion of external context in projecting behaviour makes the ABC model highly relevant when aiming to understand sustainability of occupant behaviour in sustainable accommodations.

Although the ABC model is valuable in explaining ESB, it has been recognized that it does not explain ESB that have a habitual character. Since many ESB have a habitual nature, the very

author of the theory proposes expanding the model by including habits. Habits are defined in the literature as frequently performed, automatic actions carried out in a stable context, which significantly reduce cognitive effort often to the point where no conscious deliberation is required for performing an action (Kurz et al. 2015). For instance, the way the artificial lights are used within the accommodations, waste management, heating and ventilating practices of occupants could be considered habits.

2.5.1.2. *Theory of Interpersonal Behaviour (TIB)*

Harry Triandis in his comprehensive Theory of Interpersonal Behaviour (Triandis, 1977), abbreviated TIB hereafter, besides explaining behaviour by attitudinal and external factors also considered by the ABC model, accounts for habits as well. In the model of Triandis, behaviour is driven by behavioural intentions, facilitating conditions and habits. Behavioural intentions are shaped by attitudes including the expectancy-value component which is the perceived value of the expected behavioural outcome, social factors including subjective norms, roles and self-concept, which is the perceived role of a person within the society and appropriateness of behaviour from one's perceived social role, and affect or emotion. The facilitating conditions cover the factors outside of individual agency while habits are considered as the frequency of past behaviour and it is proposed that the more frequent a behaviour the more automatic and less deliberative it becomes. ESB researchers showed decades later the proposed model has a good predictive power for those environmental behaviours that are prone to the effects of habit such as car use (Bamberg & Schmidt, 2003) but also in explaining adoption of vegetarian diets (Salonen & Helne, 2012).

2.5.1.3. *Motivation-Opportunity-Ability model (MOA)*

Another well-known behavioural model inclusive of habits was developed by Ölander and Thøgersen (Ölander & Thøgersen, 1995). The model shows similarities with the TIB and ABC models and suggests that behaviour is determined by motivation, ability, and opportunity. The "motivational" component consists of intention which is a product of attitudes and social norms. The "ability" construct consists of task knowledge and habit, the latter also present in the TIB. Finally, "opportunity" determined by situational factors relates to the contextual drivers of the ABC model and to Triandis' facilitating conditions.

The MOA model was extensively used in research investigating ESB such as energy conservation in the domestic environment (Gatersleben & Vlek, 1997, 2000; in Jackson, 2005) or recycling and waste separation behaviours (Kok & Siero, 1985; Pieters, 1989, 1991; Thøgersen, 1994; in Ölander & Thøgersen, 1995) showing that opportunities to recycle increase recycling behaviour independently from attitudes or perceived difficulties (Guagnano et al., 1995). Since the

“opportunities to recycle” are tangible constructs of the physical environment, the MOA model’s consideration of physical context needs to be acknowledged and the theory bookmarked when aiming to build an overall understanding of sustainable occupant behaviour in sustainable accommodations.

2.5.1.4. Context and the Habitual nature of residential ESB

Understanding context is becoming even more relevant when the habitual nature of residential ESB are again considered. As briefly mentioned above, habits are repetitive actions performed in a stable context and have an automatic nature since they are performed with little or no conscious deliberation. The fact that habitual behaviours are not preceded by rational evaluations, they are resistant to the effects of attitudes and other internal factors of behaviour. Nevertheless, habits have been found to be cued by recurring stimuli in a stable context (Verplanken & Faes, 1999) and are sensitive to context change. Such change is represented by moving home, which is what students experience when moving into university accommodations. Literature suggests that situational lifestyle changes such as moving home make habits more vulnerable and might offer a “window of opportunity” for reconsidering and adopting new behaviours (Verplanken et al., 2008). This means that students moving into university accommodations receive a window of opportunity for adopting environmentally sustainable behaviours that may become habits and may be cued by the physical environment of the sustainable accommodation. It also means that the behaviours studied are situated within the physical context of the accommodations, hence the reason the thesis adopts an epistemological position that looks at the situated nature of residential ESB.

This is not to say that the present thesis is driven solely by the habitual character of domestic ESB, but that the habitual characteristic of domestic ESB and the relationship of habits with their context supports investigating how the physical sustainable environment might shape environmentally significant occupant behaviour.

2.5.2. Social Practice Theory (SPT)

Shove (2010) takes a critical stance against the individualistic theories and argues that behaviour is not the right level of analysis and psychology is definitely not the right discipline for understanding and shifting environmentally affecting behaviours. Instead, it is proposed to move towards thinking about behaviours as entities embedded in a much larger vessel of social practices, which in turn drive and sway behaviours. Social practices are defined as “broad cultural entities that shape individuals’ perceptions, interpretations, and actions.” (Hargreaves, 2011). From this perspective, people are sheer “hosts” and “carriers” of practices which have their own

career and trajectory. Therefore, to understand behaviours first an understanding of practices that define those behaviours is necessary. Shove argues that in order to understand and change environmentally significant behaviour, we need to go beyond the Attitude-Behaviour-Choice model of policy making and understand practices and the way they form and are sustained by society. It is essential to mention that although Shove refers to an ABC model, this is not Stern's Attitude-Behaviour-Context model. Instead it is a model thought by Shove to be used by policy makers, where actions are a matter of individual "Choice" placing responsibility of all actions on the individual and voiding the responsibility of the policy makers.

In SPT practices are considered to be composed of three interlinked elements: meaning, procedures, and materials (Chatterton, 2011; Shove, 2010). This means that the environmentally consequential practice will be conditioned by these three elements. A good example of practices and their constituent elements is given by Hand et al. (2005) who analysed the evolution of the practice of showering and other water use patterns in Britain. While cleanliness, self-care and bodily maintenance can be interpreted as "meaning", the ability and capability to take a shower can explain the procedures or skills, while the technological development and water and heating provision can be conceived as the materials and objects (Hand et al., 2005; Pullinger et al, 2013). These elements together: the materials, the skills and the meaning form a practice.

The Social Practice Theory has been widely applied in studies concerned with sustainable behaviour such as energy use (Shove & Walker, 2014), transport or even recycling (Chatterton, 2011; Hargreaves, 2011) but also to the study of spill-over effects of sustainable behaviours (Wonneck & Hobson, 2017).

However, SPT also received criticism from Whitmarsh and their colleagues, who argue that rejecting all individual-concerned psychological research and claiming that SPT is the only useful and effective model for inducing environmental change by human action, as suggested by Shove, is not reasonable. Sustainability is considered a complex issue which, according to Whitmarsh, requires both individual and social change. While social change is definitely needed, and Shove might well be right on the underuse of sociology in environmental policy, society clearly cannot change by excluding the individual (Whitmarsh et al., 2011). Therefore, rather than seeing psychology and sociology as conflicting disciplines, a multidisciplinary approach would be more welcomed for executing effective and lasting change both on individual and on social level. Other researchers also concluded that although the two approaches, namely social psychology and sociology have a palpable tension between them and have often been presented in opposition in the context of environmentally consequential actions, reconciling the two perspectives and

integrating relevant knowledge from both traditions would be the most effective to change unsustainable behaviour patterns to more environmentally protective alternatives (Kurz et al., 2015).

2.5.2.1. *Architecture and Social Practice Theory*

Shove (2013) argues that in order to understand and change environmental practices, including the environmental behaviours, a better understanding of technology and physical infrastructure, one of the three main pillars of practices, is required. Physical infrastructures are conceptualized as relatively distinctive but strongly interconnected and potentially complex material arrangements, layouts or systems of provision which accommodate not one but many social practices (Shove, 2013). For instance, cities, streets, buildings or building appliances can be conceptualized as physical infrastructures, as complex and entangled provision systems hosting a variety of practices some of them as mundane as walking, cycling, working, learning, or even heating our home, cooking our food and maintaining bodily cleanliness. Although infrastructures in themselves are not enough for the practice to be generated and maintained, they are important not only for efficiency but also because they have the potential to enable or constrain environmental practices. For instance, just by providing a cycling path the practice of cycling will not necessarily be adhered to. However, the cycling road is a necessary element affording or obstructing the practice of cycling. Furthermore, the physical infrastructure can shape the other two major component of practice, namely skills and meaning (Shove, 2013). A good example could be the availability of electric bikes, which relies on established skills and knowledge required for riding a bike and operating battery powered devices, but it also develops new skills of using the electric bikes. Furthermore, providing bike lanes and new, easy to use bikes could make biking appealing and reshape the meaning of biking.

Adopting the same logic and putting it in context of the present investigation, the sustainable accommodations and its integrated features can be conceptualized as the physical infrastructure of environmental practices. Although sustainable accommodations as physical entities are not enough for ensuring sustainable use, based on the logic presented above, they are still important in the sense of shaping - enabling or limiting - practices with environmental consequences. However, how far sustainable accommodations as physical infrastructures enable or limit sustainable occupant behaviours and practices is unexplored. Therefore, increasing understanding on the sustainable accommodations as physical systems of provision and how those systems shape sustainable occupant practices might be crucial if supporting sustainable occupant behaviour is to be pursued in sustainable accommodations.

By using the above understanding at the design of new sustainable accommodations, or at the sustainable renovation and refurbishment of already existing accommodations, sustainable architecture might be in a strong position to provision a major pillar for satisfying SPT and to provide supportive physical infrastructure for the enactment of sustainable occupant behaviours. Furthermore, the right design of sustainable accommodations might also be in a position to shift existing skills into more sustainable direction and to change the meaning of environmentally relevant practices. For instance, well-designed ventilation facilities serving natural ventilation could change the practice of ventilation from opening the windows to using the trickle vents potentially reducing heating energy waste in the winter. But the same design feature could also change existing occupant skills to ventilate the room and could also change the meaning of ventilation.

2.5.3. Transactional psychological approaches

Transactional approaches regard behaviour as being contextualised and situated and are mainly concerned with behaviour as transactions and interactions between the environment and the individual.

2.5.3.1. *Behaviour Setting Theory*

One of the most influential behavioural theories in psychology is the Behaviour Setting Theory, developed by Roger Barker, the founder of Ecological Psychology (Barker, 1968). Barker studied human behaviour in its natural setting, outside the laboratory, and expected to find that personal characteristics such as personality traits or personal values predict behaviour. To his own surprise, he found that individual characteristics are not the main drivers of behaviour. Instead his empirical research suggested that the setting encountered by the individuals dictated their behaviours. Behaviour settings, according to Barker's work, can be conceptualized as the fusion of the physical and social environment with its written and non-written norms and rules. These elements together, the way the physical environment and its features are designed, the people in it and the norms and rules formed the setting which in turn shaped behaviour. Barker labels behaviour that is similar in structure to its physical setting, its milieu, as synomorphic. For instance, sitting in a lecture theatre during a lecture and the lecture room are in a synomorphic relationship, while standing on a chair during a lecture is not.

Although Barker's theory served as a fundamental theory in Environment-Behaviour research (Kopeck, 2012) and has also been used to understand environment-affecting consumer behaviour (Foxall, 1995), no empirical work is known to have adopted it in the study of residential

environmentally significant behaviours potentially due to the fact that psychology did not fully adopt it (Popov & Chompalov, 2012).

Sustainable accommodations, based on Barker's theory, could be conceived as settings for sustainable behaviours, consisting of the sustainable physical environment, the social environment, and the norms and rules expected to be followed in such a building. Furthermore, in case the sustainable milieu supports sustainable behaviours, the sustainable behaviours and the sustainable accommodation could be in a somewhat synomorphic relationship. While the theory offers a good conceptualisation of behaviour situated in the context of sustainable accommodations as a whole, it is challenging to apply it for understanding the interactions of occupants with the design features of the building. However, the following environmental psychology informed design theory might do just that.

2.5.3.2. *Theory of Affordances and Perceived Affordances*

The term "affordance" was originally coined by J.J. Gibson (1977) who undertook extensive and far-reaching work in the area of human perception. Gibson argues that the world and its objects incorporate attributes that allow ways of use and interaction specific to the organism or agent that may interact with the object. These potential ways of use are the affordances of an object and may be picked up by an organism via sensorial perception. Furthermore, Gibson suggests that affordances are inherent to an object independently from cognition, that is the affordance is present in an object regardless whether a person knows what the object is and how to use it or not. This means that for instance, the heating system of a home affords heating regardless of the occupants knowing how to use it, or recycling facilities allow recycling regardless of users knowing how to recycle. These examples show that although the concept may be suitable for the study of perception, it is problematic to apply it in the study of behaviour, of object-user interaction, or environmentally significant occupant-building interactions.

Nevertheless, design science adopts the concept of affordances with pivotal refinements to it (Norman, 2002). Norman agrees with Gibson on the idea that the physical environment and its accommodated features have certain properties and characteristics that function as cues on how actions can or should be performed on them, and that agents, human or otherwise, pick-up those cues via their senses. Nevertheless, he disagrees on the idea that the information is picked up directly through the senses without the need for cognitive processing. Instead, Norman proposes that the brain must first process the information received by the senses which is followed by interpretation of the information. Therefore, in his view, affordance is not equivalent with the properties of the object, as Gibson suggests, but it is instead a relationship between the

properties of the object and the abilities and capabilities of the agent. Hence, a heating system affords heating only when occupants can decipher how to turn it on, recycle bins allow recycling when occupants recognize the bins and know how to recycle, or trickle vents afford natural ventilation in rooms when occupants recognize the vents for what they are and know how to operate those.

To avoid the confusion with Gibson's term, Norman coined the term "perceived affordance" which refers to only those properties or cues of an object allowing certain actions which are perceived by the agent or which the agent is aware of. If an object affords certain actions on which the user is not aware or does not understand the cues the object sends through its properties to perform the action, then those actions are not afforded by the object for the user and these properties are not considered affordances.

The concept of Perceived Affordances has been successfully applied in research aimed at understanding occupants' recycling behaviour (Duffy & Verges, 2009). In their study, Duffy & Verges found that the presence of specialized lids on waste bins, theorized as the perceived affordances, significantly increased beverage recycling by 31%. Affordances also served as key concepts in qualitative research aimed at understanding smart meter use in residential contexts in terms of what smart meters afford to different actors (Darby, 2010).

Albeit its application is specific to object and product design, the Theory of Affordances has found its way into architectural research, where it has been applied in the context of understanding the relationship between individual building elements such as lobby, stairs, doors, door handles and afforded occupant behaviours (Kim et al., 2011; Koutamanis, 2006; Warren, 1984). Maier and colleagues also echoed Gibson when proposing the application of the concept of affordances in architecture in order to develop a "satisfactory theoretical basis" for architecture by understanding the relationship between the built environment and the occupant (Maier et al., 2009). They further suggested that in the context of architecture, the concept of affordances should be similar to its form in design science and that the built environment is equivalent with the object or artefact component while the occupant is corresponding to the users. Maier et al. proposes a categorisation of affordances linked to building scale as: high level affordances or what the building as a whole affords, such as shelter, comfort or aesthetics and low-level affordances which are related to building features such as doors, windows or floors.

Since the concept of affordances describes potential uses of an object or building, it may help understand what are the sustainable ways of interacting with a sustainable building that the

building and its features incorporate and enable. Hence the occupant may choose to use the building or its features in a sustainable way, should the latter incorporate that way of use. However, Withagen et al. goes one step further, and claims that affordances may actually “invite” ways of use (Withagen et al., 2012), which for the design of sustainable buildings means that specific features may offer or promote sustainable ways of use that are more likely to be selected by occupants than less sustainable ways of use. This may serve as an explanation for the findings of Duffy & Verges (2009) if the receptacles they studied were initially designed with the intention to suggest and invite sustainable ways of disposing of waste. However, this also means the designer must have a good understanding of how their design will be perceived by the user, an understanding that eventually matches the user perception. However, in architecture this match can be problematic as follows.

Sarah William Goldhagen in her architecture focused book (Goldhagen, 2017) echoes that people experience landscapes, streetscapes, buildings and objects based on the perceived actions these spatial entities can afford to them rather than conceptualizing these elements as abstract and passive. People are constantly looking for opportunities the built environment and its features can offer, assess their usefulness with predefined goals in their mind and ready to act. Goldhagen contrasts this mechanism of cognition, the perceived affordances, with how architects conceptualize spaces and objects as abstract compositions. She gives the example of the staircase which in her view, no matter how aesthetically appealing may be, cannot be perceived solely in its pure abstraction. Instead the staircase is comprehended, whether consciously or non-consciously, as an object or spatial composition that enables certain actions. In other words, the architects may be inclined to think about the building and its features as abstract objects in the space while the inhabitants and users think about the same entities of the space in terms of what those can offer and afford. Hence the mismatch between architects’ interpretation of affordances of a space and its features and occupants’ perceptions on what a building and its features can afford.

The gap between the designer and the user in the context of affordances of an artefact has also been emphasised by Norman. In Norman’s reasoning, there are two mental models: that of the user who is engaged in understanding how an object works and what it can afford; and that of the designer, who makes assumptions on how the designed object will be used. In felicitous cases, the two models fit relatively well, and the user can successfully decode the object’s intended use encoded by the designer. However, there are cases when the two models do not match sufficiently and because the designed objects are usually used without the presence of the designer who therefore cannot communicate their conceptual model to the user, the message

will be unclear, and the user will not understand or will misunderstand how to use the respective object, leading to the misuse of the object. The main reason behind this issue, according to Norman's views, is linked to the fact that people when interacting with their environment are functioning on three levels: visceral, behavioural and reflective. While only reflective is conscious, visceral and behavioural is unconscious (Norman, 2002). This means that most of the decisions on how to interact with their environment and its features will be based on non-conscious deliberations. That is, while people decode affordances of the objects or environments they encounter, they are in a mostly non-conscious state, on automatic pilot as it were, and are using the environment and its features intuitively. On the other hand, when designers envisage how the designed objects will be used, they think in rather rational terms, expecting the same rational approach from the user.

Being aware of this duality, of architect's conceptions and mental models of occupants' understanding and interactions with a system, and occupants understanding and interactions with the same system, might prove essential in the study of environmentally relevant occupant behaviour in sustainable accommodations. It can be argued that sustainable accommodations are usually expected to host sustainable behaviours with architects integrating into their design elements and features that are meant to afford sustainable occupant-building interactions. However, following the above logic, the "designed affordances" might not always meet the "perceived affordances" leading to undesirable and unsustainable use of the building and its features, further contributing to the already generally high environmental impact of the buildings.

2.6. Miss-matched affordances in sustainable architecture?

The above line of argumentation originating from design seems to be corroborated by a large body of building science and social science related empirical evidence suggesting that sustainable buildings and its features are not always used in sustainable ways, while the sustainable use is presumed to be the intended way of use, leading to unsustainable and environmentally pernicious use. Architects use rules of thumbs and make assumptions about how the buildings and its features will afford use and about occupants' energy use patterns. However, those assumptions are often not in line with occupant's building use behaviour, leading to a sometimes considerable mismatch which in turn constitutes a significant part of the ominous building performance gap (Brown & Cole, 2009; Guerra-Santin et al., 2014; Leaman & Bordass, 2001; O'Brien & Gunay, 2014). The architect-occupant mismatch in the context of sustainable buildings has been of scientific interest and the exploration of the topic generated several explanations for the existence of the gap.

2.6.1. Scarcity of Post Occupancy Evaluations (POE)

One of the major reasons behind the gap are argued to be the reduced number of POE studies which were designed and developed specifically to assess building performance during use (Bordass et al., 2001a, 2001b; Bordass & Leaman, 2005; Stevenson, 2019). Leaman and Bordass criticised architects and construction professionals on the premise that they rarely go back to perform POE studies and to examine how the sustainable buildings are used in real life. Therefore, according to Leaman and Bordass, as a clear consequence of not knowing the outcomes of the design architects cannot design in a way that fully matches the buildings actual use and fully supports sustainability (Bordass & Leaman, 2013).

Indeed, according to a relatively recent survey, only 3% of UK based architects perform POE regularly on housing projects (Clark, 2015) and the validity of the claim that by knowing more about how the buildings are used could yield better architectural decisions for sustainable use is hardly questionable. Nevertheless, it needs to be mentioned that the issue is more complex than just blaming architects and building professionals.

Several constraints and forces exist outside of architect's agency which might easily preclude them from revisiting the operating buildings and performing a comprehensive study on its use. Financial and time limitations, often adversarial contract structures, short term goals of clients, agency restricted to design task of the architect may be reasonable culprits, to name but a few. Furthermore, even if POE is carried out, architects might not necessarily know how and why the buildings are used differently than intended or how to better match future design intention to occupant behaviours. In a recent study by Hay et al., architects argue that the quantitative data of POE studies would need to be complemented by a qualitative understanding of how and why occupants perceive and use the designed places (Hay et al., 2017).

Therefore, an alternative and perhaps more realistic approach to help reducing the gap between the designed and actual behaviour, which the present thesis suggests, could be to develop scientific knowledge on how occupants perceive the buildings afford certain environmentally related interactions and to match that with architects' intentions to support sustainable use. This could help architects better understand how their intentions matches with real use, but it could also allow architects to understand why occupants use the features the way they do and how to design in a way that supports sustainable use.

2.6.2. The paradox of Complexity

Another possible reason behind the intended-actual use (or affordance gap) is suggested to be the Complexity. Leaman and Bordass argue that sustainable buildings and their systems are often more complex than the systems of more conventional buildings and therefore are perceived by occupants as overly complex and less straightforward to use, further posing a considerable challenge to the intended, sustainable way of use (Leaman & Bordass, 2001). Similarly, O’Brian and Gunay (2014) suggests that the way occupants interact with the sustainable building and its systems might be influenced by the availability, accessibility and complexity of building features. O’Brian also states that occupants are looking for simplicity and ease of use, and when those characteristics are missing, and the system is perceived to be too complex they might use the systems in less sustainable ways.

While understanding how the building features function is pivotal to enable and ensure the sustainable and intended use, the notion of complexity is a sensitive concept, and therefore it should be treated with care. Understanding the sometimes elusive meaning of complexity and simplicity in the context of design in general, whether objects, buildings or systems, has been acknowledged as being an ambitious challenge by Don Norman in his book, “Living with Complexity” (Norman, 2010). In this book, Norman argues that complexity does not necessarily mean that the use is unclear or difficult. Conversely, simplicity does not necessarily convey a clear message on use and can easily lead the user astray. For instance, Apple products or the Nest thermostats are complex in their functionality but generally accepted to be very easy to use. While other devices, such as thermostats, may be considered simple but difficult to use (Karjalainen, 2007). Norman argues that complexity also depends on what the use is on the specific system, who is the user, what are their abilities and capabilities and their familiarity with the system. These qualities together might define what is the desired level of complexity, the ‘sweet spot’ as Norman calls it, in a certain situation. Furthermore, when describing the ideal range of complexity Norman refers to Csikszentmihalyi’s notorious research on Flow (Csikszentmihalyi, 1997), which is the state between frustration originating from the high level of difficulty of a task and boredom coming from the unchallenging and uninteresting task. Similarly, the desired level of Complexity lies between the extremes of too complex or too simple.

Translating this idea back to the design of sustainable buildings, the complexity does not necessarily mean that users find it difficult to understand how the building and its features function. It could be that the sustainable buildings are more complex but that does not necessarily mean that their use is less well understood by the occupants. Furthermore,

considering that the focus of the present thesis is on sustainable student accommodations, the paradox of complexity is becoming even more relevant. It could be that student occupants might deal with complexity very differently and have very different expectations than more senior, seasoned building users. Therefore, comprehending how student occupants understand the use of sustainable building and its integrated features might be pivotal in supporting sustainable use in sustainable student accommodations.

Finally, in Norman's argument, the key for designers to create objects that are neither too simple nor too complex, is to have "Conceptual models" – what designers think the artefacts incorporate - of the "System image" – information the artefact incorporates and may also include user guides - that matches well with "Mental models" of users – what occupant believe or perceive of how the artefact works. In the context of sustainable buildings, this means that the architects have a conceptual model of what the building is and how it can be used by occupants which during design and construction gets materialized into the building with all the signifiers of use, handover documentation and user manuals for built-in systems – which forms the system image, and finally the occupants also have a set of beliefs about how the building and its features can be used. Based on Norman's line of reasoning the question of the right level of complexity is solved by ensuring the conceptual model of architects is closely aligned with the mental model of the user. Analogously, the present thesis reminds that both models, that of the architect and of the occupant, need to be understood and matched in order to identify good working practices but also potential gaps which if uncovered may present opportunities for improvement.

2.6.3. The Comfort disparity

Brown and Cole suggest that the human performance gap might originate from the mismatch between the assumed and actual occupant comfort and the assumed and actual comfort-related occupant behaviour (Brown & Cole, 2009). In other words, there is a difference between what comfort and behaviour to achieve comfort means to occupants and how architects and designers conceptualize occupant comfort and related behavioural responses. This discrepancy, besides obviously reducing occupants' comfort, also leads occupants to exhibit behaviours which are environmentally less supportive. Therefore, understanding and well-supporting the actual occupant comfort is vital to reduce the human performance gap in sustainable buildings.

In residential buildings, demand for comfort is found to be especially high (Hauge et al., 2010) and occupants have full freedom on how to achieve that (Tweed et al., 2014), meaning that resource intensive behaviour to support comfort may be even more prevalent than in other buildings. Furthermore, since performance expectations of sustainable buildings are far higher than of

conventional buildings, resource intensive behaviours are considered to have a more marked relative impact on sustainable building performance than on more traditional buildings. Therefore, sustainable accommodations may be particularly sensitive to environmentally impacting, comfort seeking occupant behaviours and therefore occupant comfort and the behaviours to achieve that should be thoroughly considered and adequately supported by the architectural design.

The dimensions of occupant comfort commonly discussed in the literature of sustainable buildings and their sustainable use, relate to the physical qualities of the indoor environment with focus on thermal comfort, visual comfort and good air quality (Frontczak & Wargocki, 2011). Thermal comfort is commonly associated with heating and ventilation practices, visual comfort with light use behaviour, while air quality relates to ventilation but also to ways of heating.

Although comfort is primarily subjective and closely aligned with individual perception, its support transpires into architecture and building science as a set of physical measurement and simulation exercises (Osterhaus, 2005; Zhang, Arens, & Pasut, 2011). In establishing the right comfort parameters, architecture mainly considers the results of the physical measurements and energy simulation tools using climatic, physical and thermal data (Delzendeh et al., 2017) rather than relying on occupants' perceptions and experiences. For instance, visual comfort is considered via elaborated studies of glare and brightness while predefined thermal standards indicate the right thermal comfort in buildings. But, as previously mentioned, comfort is subjective and is dependent on many factors such as personal, cultural, situational or contextual. Therefore, by only relying on the physical measurements and simulation models', architects miss out on supporting what is equally, if not even more important: the subjective, perceived form of comfort, whether visual, thermal or otherwise. The point here is not that the physical measurements and simulation models are not needed, but to emphasize that understanding of subjective experiences of occupants may also need to be integrated into the design process. However, at this point the literature does not inform on whether and how architects may consider subjectivity of occupant comfort and how their considerations may match occupant perceptions. The present study comes to fill this gap by exploring and juxtaposing occupant perceptions of comfort and architect considerations of future occupant comfort.

2.6.4. The "Passive agent" fallacy

The literature suggests that architects often conceptualize building occupants as passive agents rather than allocating an active role to them within the built environment (Brown & Cole, 2009; Zapata-Lancaster & Tweed, 2017). However, occupants actively interact with the building and its

systems and exert agency to set the desired conditions (Zapata-Lancaster & Tweed, 2017). These active interactions inevitably have an impact on the final environmental performance of the building. Furthermore, in sustainable buildings the impact of active interactions with the buildings is bigger than in more conventional buildings (Hoes et al., 2009; in O'Brien & Gunay, 2014). Therefore, the performance of the sustainable building depends very much on the quality and type of the interaction between the building and its inhabitants performed in response to changing external conditions, also called "interactive adaptivity" (Cole et al., 2008). This means that in order to ensure the effectiveness and the positive environmental outcome of sustainably designed buildings, occupants need to be conceptualized as active contributors to the performance of the building (Brown & Cole, 2009; Cole et al., 2008).

Although the argument that occupants may be conceptualized by architects as passive agents is thought-provoking, it is difficult to fully subscribe to this view and to put the architects in the unfavourable light of designing without the slightest considerations of occupants actively interacting with the sustainable building and its features. Even more that this task is present in common sustainability related professional literature (e.g. "Sustainability: RIBA Plan of Work 2013 Guide" (Halliday & Atkins, 2016)) via discussion of control strategies from concept design to handover, where design is advised to match needs and abilities of the operator and the end users who will control and interact with the building features according to seasonal variations and specific occupancy patterns. Hence, the RIBA guidance sets architects on the path to consider from the early stages of design the end users as active agents interacting with the sustainable building and controlling its appliances to set the desired conditions. However, to what extent architect's conception on occupant's agency and active role in building interactions is nuanced enough and matches with the real interactions remains unknown and is a major focus of this thesis.

2.6.5. The "Rational actor" misconception

A reason behind the designed and actual use gap may be that architects make optimistic assumptions and are believed to think of occupant behaviour as rational and driven by intent (O'Brien & Gunay, 2014), while several disciplines argue differently. First, psychology and behavioural economics has provided convincing evidence that human behaviour including environmentally significant behaviour often does not fit the Rational Model and therefore can be seen irrational, or "boundedly rational", driven by impulse rather than intent and by contextual cues from the environment (Ariely, 2008; Cialdini, 2003; Kahneman, 2012; Simon, 1957; Verplanken et al., 2008). This limitation of conceptualizing behaviour and building interactions as

rational is also acknowledged in building science, by emphasising that the way occupants interact with the building and its features is the most convenient rather than the most logical (Leaman & Bordass, 2001 in Brown & Cole, 2009). Architectural scientists and critics also remind us of the partly rational character of behaviour when describing how behaviour within the built environment may be driven by evolutionary traits and tendencies (Gehl, 2009; Goldhagen, 2017; Sussman & Hollander, 2015; Whyte, 1980). Design science also suggests that designers and architects often design with a rational mindset while users and occupants use the built environment and interact with their features in a rather intuitive manner, thus the discrepancy between the architect's or designers' assumptions and expectations on use and the real use (Norman, 2002).

On the other hand, O'Brien & Gunay (2014) admit that although behaviour might not be fully rational, "it is also hard to argue that occupants are fully irrational". Instead, they suggest, occupants want to restore their comfort in the easiest possible way, but the contextual factors might stand in their way making occupant actions seem irrational. Zapata and Tweed (2017) also argue that occupants are in fact rational actors who will exert agency over their physical environment and insists that architects and designers should consider that in order to support occupant comfort and sustainable use. Norman (p.49-55,2002) also agrees that out of the three levels of human interaction with the physical objects of the space, one is rational. However, he reminds us that the two other levels of decision-making are in the irrational range, such as visceral and behavioural, suggesting that although there might be rationality involved in the way people interact with objects most of the interaction will be irrational and unconscious pushing the pendulum back to the irrational side.

Although behaviour may be mostly irrational or non-rational, Ariely in his famous book titled "Predictably Irrational", suggests that it is still predictable (Ariely, 2008). Sunstein and Thaler in their cornerstone book titled "Nudge: Improving Decisions about Health, Wealth, and Happiness" also suggest that although people are biased in their decision making and are inclined to act in a way that is familiar, comfortable and convenient rather than in their interest, designers can build on those flaws and biases and nudge behaviour towards more beneficial directions (Thaler & Sunstein, 2009). This concept is further supported by O'Brien & Gunay in the context of sustainable buildings who suggest that resource related use of the building can be predicted since occupants interact with the building to regain their comfort and when their comfort is missing exaggerated measures are taken to regain it rather than acting in fine-tuned manner (O'Brien & Gunay, 2014). While these claims are promising, how far architects consider the irrationality of

occupant behaviour and predict resource related use of the sustainable buildings based on comfort restoring rather than fine-tuned building interactions and design to support sustainable use, is largely understudied.

2.6.6. The Universal solution

Finally, it is also suggested that architects' decisions of following and heavily relying on the principle of "one-size-fits-all" in their designs could be part of the reason behind the architect-occupant gap and the consequential outcome of unintended and unsustainable building use. However, occupants cannot be conceptualized as the "typical user" but instead they showcase diversity (Zapata-Lancaster & Tweed, 2017; Zhang et al., 2011). Therefore, in order to support sustainable occupant-building interactions, design may need to develop specific understanding on occupants by building types but also by other traits inherent to occupants such as comfort expectations, complexity perceptions, age and other demographic characteristics, or roles they fulfil in the building and potentially design using well-developed "personas" that may capture potential interactions between occupants and building features (Zapata-Lancaster & Tweed, 2017).

However, the present study argues that solely based on existing building user reports or on database reviews - which is the case for the referenced studies - it is challenging to conclude that the design indeed was developed for the benefit of a "typical user" not foreseeing the variety of users and uses. It may well be that the architects did make provisions for a variety of users and ways of use while the actual occupant behaviours still have limited overlap with the projected use, meaning the gap is of a qualitative nature. For the present thesis this suggests that a thorough full understanding of students inhabiting the accommodations is needed in order to comprehend their environmentally significant building interactions, on one hand. On the other hand, it is also a call to investigate the architectural intentions and capture architects' projection on the future, idiomatic use of the accommodations they design and potential idiosyncrasies in student occupant behaviour they foresee in their designs.

2.6.7. Conclusion

It is often suggested that for sustainable buildings to function effectively in terms of environmental impact and carbon footprint it is vital that the buildings and its features are not only designed with sustainability in mind but are also used sustainably. However, the literature suggests that paradoxically, sustainable buildings do not always ensure sustainable use. While there could be several reasons behind the unsustainable use of sustainably designed buildings, one prominent reason is believed to be linked to the architect itself. More specifically it is often

suggested that architects, although intend to support sustainable use, often lack nuanced understanding and therefore misinterpret occupant environmentally related behaviours and sustainable building interactions in their designs, leading to the mismatch between the intended use and actual use and consequently to the unsustainable use of the sustainable buildings. The literature-informed fallacies identified in this section provided some possible explanations why architects may be misinterpreting and predicting occupant environmentally significant behaviours differently from how occupants actually use the sustainable buildings. The lack of follow-up studies on how the sustainable buildings are used, the design of overly complex and uncomfortable systems, the lack of considering occupants as active agents with often irrational and less conscious decision-making and the ignorance of diversity among occupants were some of the explanations presented in the present section. As logical as these explanations might sound, it is important to remember that they are mainly research speculations rather than empirically supported findings. Speculations, since none of the studies suggesting the plausible sounding explanations on the provenance of the architect-occupant gap considered the architect's intentions based on data collected from the architects themselves. In this sense, these studies are skewed since they only consider the occupant perspective and behaviour but are missing out the architects' intentions while making assumptions on the reasons behind the architect-occupant gap. The contention of this thesis is that it is not possible to know the real reasons behind the mismatch without considering both perspectives: that of the architect and of the occupant. For instance, it might well be that while common sense would dictate that the architect was not versed enough to design for the real occupant comfort, the factual reason behind the mismatch is outside architects' agency and lies in client requirements or other constraints. Or indeed, it could also be that talking about the intended-actual behaviour gap is not reasonable and legitimate if architects did not have any intentions to support a specific behaviour. It may also be that architects misinterpret what comfort means for occupants. However, even if that is the case, without understanding the architect perspective, it is not known how occupant comfort is interpreted by architects and how that differs from the interpretations and comfort expectations of occupants. Therefore, the thesis argues that in order to understand the nature and reasons behind the mismatch both perspectives, that of the architect and of the occupant must be identified, evaluated and compared.

2.7. Conclusion of the review and Research questions

The present review finds that there is a solid theoretical and empirical foundation to aspiring to promote sustainable occupant-building interactions by architectural design of sustainable accommodations. However, when sustainable buildings including sustainable accommodations

are assessed during use, occupant behaviour does not seem to be as environmentally sustainable as expected. While there might be several reasons behind the sustainability-wise unsatisfactory behavioural outcomes, one prominent explanation is that architect's assumptions on how the sustainable accommodations and its integrated features afford sustainability related occupant behaviour and use is not in line with occupants' perceptions on how the sustainable building and its features afford sustainable behaviour and use. With other words, it is assumed that there is a gap between the intended and actual sustainable behaviour affordance of the sustainable building. While this explanation might sound plausible, there are very few empirical studies providing deep insight of occupant's perceptions on how the sustainable building affords sustainable use. Furthermore, architects' assumptions and intentions to afford sustainable use by sustainable building design are mainly speculated in the literature rather than based on architects' expressed assumptions and intentions. In the context of sustainable student accommodations and their sustainable occupant behaviour affording qualities, empirical studies on occupants' perceptions, architects' intentions and how the two overlap are literally non-existent. The present study comes to fill this knowledge gap by answering the following research questions:

- *How do occupants of sustainable student accommodations perceive the building affords environmentally sustainable behaviours and building interactions?*
- *How do architects of sustainable student accommodations intend to support sustainable occupant behaviours and building interactions by their designs?*
- *How do occupant perceptions compare with architect intentions and what are the good practices and the opportunities to better afford environmentally sustainable occupant behaviour by the design of sustainable student accommodations?*

3. Research Methodology

3.1. Overall approach

To build a consistent image on how sustainable student accommodations might afford sustainable occupant behaviours, the research gathers data from occupants and architects of sustainable student accommodations across the UK. The research consists of three main empirical research strands and a fourth step that interprets together the data gathered and the knowledge developed in the three empirical studies. The three empirical studies employ mixed, qualitative and quantitative methods in order to ensure triangulation of the results and to define their complementariness (Lorenzoni et al., 2007). The fourth study analytically compares the findings of the three empirical studies. Below a short description of each of the four studies is provided. Detailed description of the methodologies employed in each study will be provided in the individual chapters dedicated to each study.

The **Occupant Interview Study** aims to answer the first research question and explores young adult occupants' perceptions and experiences of moving into and living in energy efficient residences, the reported environmentally significant behaviours, actions and interaction within and with the accommodations, and the perceived ways the built environment helps or stands in their way in adopting environmentally friendly behaviours and building interactions. The study uses Grounded Theory - abbreviated as GT hereafter - as main qualitative research methodology as it aims to generate a theoretical understanding based on the data gathered from semi-structured, in-depth, face-to-face interviews. Additionally, diaries, visual materials and observations of the site also consolidate the study as secondary data source.

The **Occupant Survey Study** verifies quantitatively the theoretical understanding and the most prominent findings of the Occupant Interview Study. It consequently translates key inferences of the Occupant Interview Study, namely how the physical, built environment of the accommodations might shape sustainable occupant behaviours and building interactions, into a questionnaire and uses online survey as main data generation technique. The data is analysed quantitatively using descriptive and inferential statistics, underlining where the qualitative theoretical inferences are supported quantitatively, further increasing the validity of the study. The results developed by this study contribute to answering the first research question.

The **Architect Interview Study** aims to answer the second research question and to understand architects' intentions when designing sustainable student accommodations, and how those intentions include the support of sustainable occupant behaviours and building interactions. The

study builds on data from face-to-face, in-depth, semi-structured interviews performed with architects of the selected accommodations as main dataset, while it uses visual materials and observations from site visits, and architectural project documentations where available as secondary dataset. The study partially builds on Occupant Interview Study by asking site-specific questions that had been made relevant by occupant accounts. The interview data is analysed with Thematic Analysis – abbreviated TA hereafter.

Finally, the **Comparative analysis** based on the results of all three empirical studies mentioned above will be performed to provide legitimate answers for the last research question of the thesis, and to explore the ways sustainable student accommodations might shape and support sustainable occupant behaviours and building interactions. This exercise utilizes the inferences of Occupant Interview Study and compares that with the inferences of Architect Interview Study in order to find good practices (overlaps) but also opportunities for improvement (gaps) in supporting sustainable behaviour of occupants by design. Additionally, it utilises the results of the Occupant Survey Study to assess what are the significant gaps and overlaps between occupant perceptions and architect intentions.

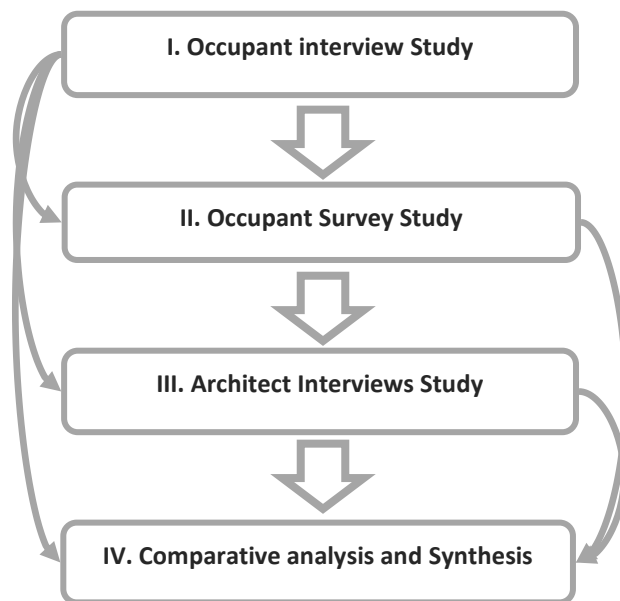


Figure 1. Sequence of the studies

Figure 1. shows the sequential organisation of the studies. The curved arrows signify where the results of one study inform the subsequent investigation.

3.2. Investigated sites

To build a consistent image of how sustainable student accommodations might afford sustainable behaviours, the research gathers data from occupants and architects of the same buildings. For

selecting accommodations with high sustainability indicators, the research defined as site selection criteria having the following certifications:

- BREEAM Excellent or Outstanding
- Gold or Platinum LEED Certificate
- Passivhaus standard
- Energy Performance Certificate Band A

The research contacted fifteen UK sites that complied with the predefined selection criteria. Out of the contacted sites, four were successfully recruited (Figure 2). All the retained sites had the same sustainability certificates and had several building blocks functioning as accommodations. Below more detailed information on the participating sites and the buildings accommodated by the participating sites is presented.

Table 1. Location, sustainability certification and capacity of building sample.

Site	Operator and location	Rating & Cert. No.	Site capacity
Mountain Halls	University of South Wales, Treforest	75.1% Excellent BREEAM-0044-8225	5 buildings, 476 beds
Daniel Defoe Hall	University of Greenwich, Greenwich	73.1% Excellent BREEAM-0039-1839	3 buildings blocks, 355 beds
Peel Park Quarter	University of Salford and CLV UK, Salford	77.3% Excellent BREEAM-0060-0403	8 building, 1367 beds
Crome Court	University of East Anglia, Norwich	78.9% Excellent BREEAM-0058-9069	1 building, 231 beds
Total			17 buildings, 2429 beds

Certification numbers retrieved from www.greenbooklive.com

“Table 1. Location, sustainability certification and capacity of building sample.” makes it immediately noticeable that all four accommodations composed of 17 building blocks in total are BREEAM certified and no building has another well-known sustainability certification. A possible explanation for having only BREEAM certified buildings in the sample is the high prevalence of BREEAM certification in the UK, and the dramatically lower occurrence of other certification methods. However, having buildings with identical certifications increases the quality of the investigations by making the sample more homogeneous and likely increases the validity of the overall study. Homogeneity of the building sample is further underlined by the similarities in the architectural style and appearance of the buildings and the layout of these buildings. All buildings are composed of rectangular volumes, accommodating several stories and a flat roof. The main finishing materials include wood, plaster, metal planting, and glass. Inside, the buildings accommodate similar style en-suite rooms of 12-16 sqm, grouped into apartments, and a small number of studio flats, for undergraduate and postgraduate student residents. Furthermore, the

buildings also have similar sustainability supportive features and technical equipment. For instance, all the buildings have LED lighting in the rooms, PIR motion sensors in kitchen and communal areas, double glazed and partially openable windows, shading devices adjusted in the exterior or interior of the windows, most have trickle vents for natural ventilation adjusted on the window frame, CHP heating system with adjustable radiator valves or thermostats in the rooms, stairs for sustainable vertical circulation and waste management and recycling facilities inside and outside the flats. Some of the buildings have PIR motion sensors in the bathrooms, low-flow shower heads and taps, greywater recycling, PVC panels, timber structure, energy information displays in the communal areas, sustainability symbols such as green walls, decorative elements raising awareness and/or bicycle storage actively supporting sustainable transportation. “Table 2. Sustainable design features by location.” lists the sustainability supportive design features known to operators or noticed by the researcher on site visits, including the location of the features within the building and associated control type where applicable.

Table 2. Sustainable design features by location.

Site	Design feature	Location	Control type
Mountain Halls	LED lighting	Across the building	Manual in rooms and bathrooms; Automatic (PIR sensor) and Manual in Kitchens and living rooms
	Double glazed windows	Across the building	
	Partially openable windows	Across the building	Manual control
	Window shading - louvers and blinds	Rooms and kitchens	Manually controlled blackout blinds Fixed louvers
	CHP heating system	Across the building	Centrally controlled
	Radiators valves	Across the building	Manual control by room
	Waste separation and Recycling facilities	Kitchen and communal areas outside of the building. Some rooms have recycle bins.	Manual control
	Low-flow shower heads and taps	Bathrooms	Manual control
	No elevator		
Daniel Defoe Hall	LED lighting	Across the building	Manual in room and bathrooms; Automatic only (PIR sensor) in Kitchens and living rooms
	Double glazed windows	Across the building	
	Generous glazing	Kitchens	
	Moderate windows size	Rooms (to control overheating)	
	Partially openable windows	Across the building	Manual control
	External window shading and blinds	Rooms and kitchens	Manually controlled blinds Fixed exterior panels
	CHP heating system	Across the building	Centrally controlled
	Radiators thermostats and valves	Across the building	Manual control by room

	Waste separation and recycling facilities	Kitchens and communal areas outside of the building	
	Trickle vents	On the window frame in student rooms	Manual control
	Green area	Courtyard	
	Cycle hub and cycle hire	Courtyard	
	Bicycles on the entrance ceiling	Main entrance	
Peel Park Quarter	LED lights	Across the building	Manual in room; Automatic (PIR sensor) and Manual in Kitchens and living rooms; Automatic (PIR sensor) in bathrooms
	Double glazed windows	Across the building	
	Partially openable windows	Accommodation	Manual control
	Window shading - blinds	Rooms and kitchens	Shafts for exterior waste separation
	CHP heating system	Accommodation	Centrally controlled
	Radiators and thermostats	Accommodation	Manual control by room
	Waste separation and Recycling	Kitchens and communal areas outside of the building	
	Low flow shower heads and taps	Bathroom	Manual control
	Energy information display	Kitchen/living area Communal entrance area	
Crome Court	LED lights	Across the building	Automatic (PIR sensor) and Manual in Kitchens and living rooms; Manual in rooms
	Double glazed windows	Across the building	
	Generous glazing	Kitchen	
	Full height windows	Across the building	
	Partially openable windows	Across the building	Manual control
	Window shading – recess, panels, blinds	Across the building	Manual control over blinds in rooms
	CHP heating system	Across the building	Centrally controlled
	Radiator valves	Rooms	Manual control by room
	Trickle vents	Rooms	Manual control

	Greywater recycling		
	Energy information display	Kitchen/living area	
	PVC panels	Rooftop	
	Living green wall	Façade	
	Wall extract showing the CLT structure	Corridor	
	Safe bicycles stand	Next to the building	



Peel Park Quarter, Salford



Crome Court, Norwich



Mountain Halls, South Wales



Daniel Defoe Hall, Greenwich

Figure 2. Participating sites.

4. Occupant Interview Study

4.1. Introduction

The present study opens the line of enquiry that builds up this thesis. It is primarily concerned with understanding environmentally significant occupant behaviours in sustainable accommodations and the relationships the sustainably built physical environment of the accommodation may have with the sustainability of occupant behaviours. In the literature review, it was found that although there are theories of behaviour that ascribe some agency to the built environment over environmentally significant behaviours, how occupants behave in sustainable accommodations, why they behave the way they do and how their environmentally relevant behaviours are shaped by the physical environment of the sustainable accommodations is largely unexplored. This is especially of concern considering that buildings, even sustainably designed buildings, have a major impact on the environment, building-use significantly contributes to that impact, which in turn may be determined by the way the built environment is designed. Hence, it is of crucial importance to understand the relationship between the sustainable building and sustainable occupant behaviours and the potential impact the designed, physical environment of the sustainable buildings have on those behaviours. This leads the thesis to formulate its first research question, which the present study aims to answer:

How do occupants of sustainable student accommodations perceive the building affords environmentally sustainable behaviours and building interactions?

As the research question indicates via the use of the word “affords”, the study acknowledges that the Theory of Affordances (Gibson, 1977) and the design-embraced concept of Perceived Affordances (Norman, 2002) may be instrumental in understanding occupant-building interactions. However, the present investigation is concerned with buildings and occupant-building interactions while the concepts around Perceived Affordances were developed in the context of artefact design and interactions. Additionally, considering that the topic of interest is largely unexplored, the study takes an exploratory stance without imposing a predefined theoretical framework. Hence, it remains theoretically agnostic and intends to develop and build a theoretical understanding from original, first-hand occupant data.

The chapter will proceed towards the Methodology section describing the methodological considerations, sampling and participants, the data gathering protocol and the data analysis. This will be followed by the detailed presentation of the major inferences in the Results section. Finally, the chapter will end with concluding remarks captured in the Conclusion section.

4.2. Methodology

4.2.1. Methodological considerations - Grounded Theory

Having visited the literature and having found only partial and somewhat inconclusive answers to how sustainable behaviours may relate to - and be swayed by sustainable buildings, the study starts from the premise that an open-minded exploratory investigation may aid finding a consistent answer to its question. While it acknowledges theories discussing the context driven nature of environmentally significant behaviours and uses the Theory of Affordances as the main informing theory, it aims to allow the data to reveal potentially significant behaviours, actions and interactions without necessarily adhering to the informing theories. Hence, it plans to “get through and beyond conjecture and preconception to exactly the underlying processes of what is going on, so that professionals can intervene with confidence to help resolve ... main concerns” (Glaser, 1978 in Calman, 2006). This aim resonates well with the path the qualitative research methodology of Grounded Theory suggests and leads the investigation to adopt Grounded Theory (Glaser & Strauss, 1967) as its main investigation and analysis method. GT is a well-known and widely used, rigorous and systematic analytical methodology, ideal for the investigations of actions and processes in their contextual surroundings (Charmaz, 2006; Clarke, 2013) and for answering “why and how questions related to human decision making and action - questions that frequently interest architects and designers” (Bollo & Collins, 2017). Furthermore, GT exhorts the development of theories or theoretical understanding(s) from the data itself instead of anchoring an investigation to a predefined theory or analytic concept, which well-fits the overall stance of the present study. Therefore, the present investigation adopts GT as main research methodology. More specifically, it adopts the Charmazian version or Constructivist Grounded Theory (abbreviated as CGT hereafter) (Charmaz, 2006). What really differentiates CGT from the other, more objectivist or positivist approaches of GT is its claim that the knowledge arising from research is co-constructed (Mills et al., 2006). What this really means is that the researcher develops the codes, categories, and the theoretical understanding from the data, imbued with their own views, beliefs, preconceptions, or backgrounds whether disciplinary or otherwise, rather than considering these analytical entities unequivocal, present and ready to be extracted from the data. This constructivist, also called ontologically relativist, approach had already been palpable in work of Strauss and Corbin, nevertheless Charmaz was the first who openly described her method as Constructivist Grounded Theory (Mills et al., 2006). In Charmaz’s view, which this study closely embraces, it is the researcher who develops the knowledge or the “reality” by interpreting participants’ accounts and hence the reality developed in this way will be inevitably influenced and permeated by the researcher’s own characteristics. This also means that the

developed “reality” is thought to be one of many rather than the imagined as an absolute reality which resides within the data independent of the researcher and ready to be extracted.

There is a growing recognition of CGT as a research method in built environment research (Allen & Davey, 2018) and it has been successfully applied in earlier architectural research investigating meanings, perceptions and experiences. In Donna Wheatley’s research on experiential interpretations of workplace design described in *Architectural Research Methods* (Groat & Wang, 2013), in studies investigating occupancy of affordable housing (Bollo & Collins, 2017), in Clarke’s thesis investigating perceptions of eco-friendly education and knowledge centres in the UK (Clarke, 2013), in studies looking at the influence of design, operation and occupancy on power plugs use in student residence halls (Bollo & Collins, 2017) to name but a few. This suggests its feasibility for the present study.

Use of other exploratory research methods, where investigations don’t necessarily rely on pre-defined opinions or notions, was omitted mainly due to their less-explanatory and theory generation-lacking aspect. For instance, Interpretative Phenomenological Analysis was considered since it allows in-depth explorations of personal and lived experiences and making sense of that experience (Bryman, 2012) but was dismissed due to its unsuitability for generating an explanatory theory. Ethnographic traditions are also inclined to produce descriptive results (Groat & Wang, 2013) rather than develop theories with explanatory power.

The primary data is generated through in-depth, face-to-face, semi-structured interviews which is an ideal main data gathering technique for GT. Individual interviews were also selected since the mundane but sometimes abstract character of the topic, namely environmentally significant behaviours require a method of rich data generation, where the researcher can prompt for more relevant matters of interest and the participants can express themselves freely. Additionally, understanding resident perceptions and experiences of acting and interacting with sustainable student residences as well as the perceived impact of the sustainable environment on their sustainable behaviours, also pointed into the direction of in-depth, face-to-face interviews.

Alternative data generation methods were evaluated and eventually excluded. Resource metering, physical measurements, surveys or observations were dismissed since these cannot discover and explain perceptions and why and how occupants behave. Additionally, observations were excluded since observing participants in their private environments poses unsurmountable privacy concerns. Finally, focus group interviews were contemplated but dismissed for two reasons. First, group discussions on behaviours performed in private environments may be

sensitive and may prevent participants from freely sharing their thoughts. Second, it can be assumed that in sustainable university accommodations sustainable lifestyle may be the social norm, potentially leading to response bias as occupants may be inclined to report behaviours they think may adhere to that norm.

In order to facilitate the involvement of the young adult occupants in the research process, additional data gathering methods were also deployed similarly to Toth and their team (Toth et al., 2013) who aimed to engage teenagers with their research. Given the invisibility of many energy behaviours and practices (Toth et al., 2013; Fischer, 2008; Darby, 2006) performed in the domestic environment, and the potential difficulty for participants to explain views on such an abstract and intangible topic, additional, secondary data gathering techniques were also employed by requesting participants to provide diaries and photos before the interviews. These materials were expected to help participants better associate and conjure up memories regarding their environmentally affecting household behaviours, making the topics less abstract and more familiar for the interviewees by the time of the interviews. Moreover, given that during the interviews participants might be biased by trying to give answers they think are appealing to the interviewer, also a kind of response bias, and as such their self-reports might not produce an accurate depiction of their actual behaviours, the diaries and photos are expected to help the participants to give an account on their daily environmentally relevant practices without having the researcher physically present, which might in turn reduce the urge to comply with the thought expectations of the interviewer. Besides the aim to aid the interviewees in revealing their realities during the interview process, the secondary data also aims to help the researcher in getting insight on participant's physical environment, their daily routines and in preparing with bespoke questions in case the topics would be too difficult or too abstract to relate to for the participants. Finally, the secondary data is expected to consolidate the findings surfaced from the interviews and to be analysed together with the interview data. Despite the important role of the secondary data, it was expected that only some participants would provide photos or diaries. For the cases where photos and diaries would be missing from a given participant but would be provided by another participant resident of the same site, the researcher would reuse the available photographic and diary data to create location specific prompts that can be used in all interviews of the same site. This way, not having secondary data from a participant would not diminish the value of their interview.

4.2.2. Participants

Participants were sampled from four, highly sustainable, pre-selected student accommodations across the UK. The participation criteria requested the candidates to be residents of the respective sustainable student accommodations. Recruitment was performed by displaying invitation posters in the communal areas of the selected student residences, by advertising the study on the social media platforms provided by the participating universities, and by contacting participants through email. Participants contacted via emails or other social media platforms received reduced number of electronic invitations. All participants were contacted indirectly, through the University they were attending or through the Accommodation Services of each site. Snowball sampling was also used by encouraging participants to bring to the interview a friend who lives in the same residence, since this allowed the researcher to identify potential participants with similar living conditions and to invite them to participate in the study.

In total, twenty (n=20) face-to-face, in-depth, semi-structured interviews were conducted with students living in the accommodations from four sites. The table “Table 3. Details on occupant sample.” below shows the sample of participants from the selected student accommodations. The number of participants has not been predefined at the beginning of the sampling but has surfaced from theoretical sampling, characteristic to Grounded Theory. Theoretical sampling states that data should be gathered until no new theoretically significant data arises that could feed the theoretical direction.

Table 3. Details on occupant sample.

Site	Building characteristics	No of participants	Gender distribution	Origin
Mountain Halls	5 buildings 476 beds	5	2 females 3 males	2 UK 3 Overseas
Daniel Defoe Hall	3 buildings 355 beds	3	0 females 3 males	3 UK 0 Overseas
Peel Park Quarter	8 building 1367 beds	7	3 females 4 males	5 UK 2 Overseas
Crome Court	1 building 231 beds	5	2 females 3 males	0 UK 5 Overseas
Total	17 building 2429 beds	20	7 females 13 males	10 UK 10 Overseas

In other words, theoretical saturation is reached when the new data does not add any significant knowledge to the topic of interest. In the present study, theoretical saturation meant that the latest set of occupant interviews did not reveal any significantly new knowledge on how occupants perceive the sustainable accommodations shape sustainable behaviours, but repeated the same patterns as the participants’ accounts from the previous interviews.

4.2.3. The data gathering protocol

The primary data was generated through in-depth, face-to-face, semi-structured interviews. The interview process was aided by an interview schedule which guided rather than dictated the discussion. The schedule evolved during the interview process, a technique specific for CGT. This means that while at the beginning the questions were broader and more inclusive since there was very little knowledge on the topic of the study, later as the knowledge was developing based on the already performed interviews, the questions became more specific.

The evolving research schedule, whether in its early or later stage, contained open-ended questions allowing participants to freely reveal their perceptions and experiences of living in and interacting with their sustainable accommodations. The interviews were constructed around the following main topics:

- **The meaning and experience of moving into and living in energy efficient student accommodations** - which served as an introductory topic for participants to help them recollect how they selected and first encountered the accommodations and what their day-to-day life was like in their “new home”;
- **Occupant perceptions and experiences on the physical environment of the accommodations** – by these topics, participants were encouraged to reveal how they experienced the visible and tangible but also invisible or intangible qualities of the space such as lights and air quality, or temperatures respectively.
- **The environmentally significant behaviours and practices performed in the sustainable student residences** - where participants were encouraged to discuss those mundane, day-to-day behaviours within the accommodations that may have been significant sustainability-wise;
- **The perceived influence of the sustainably built physical environment on environmentally significant behaviours of occupants** - where occupants could go into details about how they perceived the sustainable buildings and its features might help or hinder them in acting and interacting with the building in environmentally sustainable manner;

The main topics were complemented with subtopics and prompts to elicit rich responses, and help participants reveal their thoughts when a question may be too abstract for the participants. The interviewer navigated across the topics and subtopics and sometimes changed the order or the content of questions as seen fit. However, considerable attention was given to including all the main topics in each interview, and to asking all the main questions from each participant with the final aim of making the results comparable within and across locations and interviews. The

interviews also used indirect questions occasionally to help participants express what they felt and mitigate response bias. The indirect questions asked participants to convey what 'others living in the same accommodations' or 'their friends' could be thinking about or doing in the sustainable accommodations. The interview schedule is included in the Appendix 10.2 of this thesis.

The interviews were conducted during site visits organized in February, March, April and November 2016. All interviews took place in quiet and comfortable places, near the studied environments, usually in communal but tranquil locations on the campus. Participants were informed about the aim of the study, about what the interviews entail and about their rights as participants, via the poster and/or email invitation they had previously received. However, before the interviews, the researcher briefly described again the aim of the research and provided the participants with the Information Sheet and the Consent Form. The researcher asked participants to read the Information Sheet and the Consent Form and, if they had no further questions, sign the Consent Form. All participants reported to understand the aim of the study and their right as participants and signed the Consent Form. To ease participants before the interview, they were asked to choose pseudonyms for themselves if they wished so. This was meant to be a playful way of creating a good rapport between the interviewer and the interviewees. The selected pseudonyms were used later for reporting the recounts in anonymous, unidentifiable form. The names of those who decided not to ask for pseudonyms were also anonymized with pseudonyms chosen by the researcher. The result section uses the pseudonyms when reproducing participant recounts, together with an abbreviated name of the site where the data has been collected. Hence, each quotations of participants are preceded by "*(Name@AbbreviatedSiteName)*". Finally, participants were asked to complete a demographic questionnaire composed of ten questions focusing on general information such as age, gender, length of stay in the sustainable accommodation and type of residence. The demographic questionnaire also prompted for student awareness on the sustainability rating of their accommodations. The information gathered helped the researcher put findings in context. The discussions lasted between 40 minutes and one hour with many participants explicitly stating that they enjoyed the interviews. The collected data was tape recorded, with the written consent of respondents, and transcribed word-by-word.

Although all interviews provided useful data, some were more telling than others. While the first set of interviews were more informative and exploratory, the later interviews were more confirmatory on the developing theoretical understanding initially indicated by the first set of

interviews, in accordance with the principles of CGT. Also, some interviews, even within a set, were richer, more telling and more nuanced than others. This depended on how talkative participants were, how willing they were to share their experiences on the accommodations from a sustainability perspective, and on the rapport the researcher managed to build with the participant. Nevertheless, all interviews added to the developing knowledge base, and provided consistent and valid data for the present study.

The generation of interview data was aided and complemented by diaries written by participants and by photos taken by participants. The students were asked to describe their actions performed in the student accommodations, which they thought might have impacted on the environment. They were also asked to take photos on the same subject. Participants were encouraged to express themselves freely while writing about what actions they performed in their residences, about how they performed those actions and about why they performed the actions the way they performed them. Students were asked to confirm they understood what they had to write and when they had any questions the researcher provided further guidance about how to approach diary writing. Participants were asked to write only short notes of their daily actions, using a guiding word count of 100 words per day. This was necessary since longer diaries might have been found laborious by students, possibly leading to more reduced participation rates. However, there was no imposed upper limit on the length of the diary, nor was there any restriction on the format or style of the diary. Thus, the participants were free to write the diaries on paper, on their computer or on their phones. The free style of the content and format of the diaries was expected to motivate participants to get involved with the studied topic, and to make the activity as easy and frictionless as possible. The sole stipulation was to send in the entries one day before the interviews the latest, so the researcher would have had enough time to read the entries and to prepare with bespoke questions if appropriate. The bespoke questions were important to make the interviews more specific and tailored, hence more personal, potentially helping the participants in eliciting rich responses. Furthermore, diaries were also expected to help focus participants' attention on the relatively abstract topic of environment affecting behaviours and to be more fluent during the interview. The expectations proved right since the participants later confirmed the facilitating nature of the exercise, by stating the diary writing helped them realize what mundane actions they performed and made them think more about how that might have impacted on the environment. There was equally feedback from students mentioning they enjoyed writing the short diary entries. In total, 9 participants provided diaries and 10 provided photos pertinent to their accommodations. The additional material were also a useful support for the interviews in the sense that it helped interpret some of the statements from the interviews

and were included in the analysed text as part of participant recounts of their actions. The photographic data provided by the participants was used to develop insight on the physical context of which the participants spoke. It helped construct a more complete image of how student flats were from the occupant perspective, of the way students might have used those spaces, and helped relate to how they might have felt in - and experienced those environments. Therefore, the diary entries - where provided - from an integral part of the analyses.

4.2.4. Data gathering and analysis cycles

The present research gathered and analysed the data in iterative, cyclical manner, in line with GT, with each of the four sites providing one set of data and each site-specific dataset being collected and analysed in one effort. The gathered data and its preliminary analysis from the first site, which was Mountain Halls, suggested a preliminary theoretical direction but also guided and shaped the interview schedule for the second site, Daniel Defoe Hall, making the interview questions more honed and more specific to the developing theoretical direction. After the interviews from the second site had been collected and analysed, the findings relevant for the developing theoretical idea had been evaluated and integrated into the developing theoretical understanding. As such, by comparing the findings from the second dataset with the findings from the first dataset, the theoretical direction suggested by the first dataset has been updated and refined. Additionally, just as in the previous case, the second data analysis enabled the researcher to ask even more specific questions on the studied phenomena in the subsequent data gathering sessions. Therefore, the interviews performed on the third site, Peel Park Quarter, and the questions constituting the interview schedule and guiding the interviews became even more focused on the developing theoretical understanding than in the previous stages of data gathering. Thus, the theoretical understanding and the interview process, just as the specificities of the questions from the interview schedule were constantly evolving. It is important to note that this does not mean that the interview schedule had been changed to a degree that different questions had been asked from the participants of different sites. Instead, it gradually evolved in the sense that the questions were still the same but while some came more in focus and went deeper, as it seemed to be more relevant for the context of the study, others, which during the course of the interviews proved to be less relevant for the studied setting became more silent. The same principle was applied for the fourth site, Crome Court, as well. Given that in the fourth data gathering session participants' accounts did not reveal significantly new findings that could add to the developed theoretical understanding, theoretical saturation had been reached, also called the "saturation of the theoretical concept" (Charmaz, 2006) signalling the end of the data gathering process.

An example for the above-mentioned refinement of questions aiming to support the emerging theoretical direction can be given as follows. In the interviews of the first site, Mountain Halls, the analysis of the participants' accounts revealed the inherent need for having privacy in rooms and the reaction the lack of privacy elicits namely, to close the blinds and to turn on the lights. After this phenomenon was surfaced as something potentially specific for the context of student accommodations, the researcher focused more on this area during the interviews on the second site, Daniel Defoe Hall, by prompting more deeply on how occupants sense their room affords privacy and what are the related mechanisms and reactions to that sensation. The second site data analysis revealed that although this might be a prevalent pattern in student accommodation, it might also be driven by the floor level students reside on, the perceived visibility from the adjacent building blocks and the distance of the sidewalks from the building. The same assumption was further supported by the results of the interview analysis from the third site, Peel Park Quarter and the fourth site, Crome Court.

4.2.5. Data analysis process

Assessing the researchers' influence

Before embarking in the data analysis process, the researcher - in line with CGT - acknowledged the influence the researcher likely has on the data analysis, and invested time and effort to assess and evaluate what they personally brought to the data analysis. More specifically, the researcher reflected upon how their views, beliefs and experiences on the topic of interest but also on the momentary perceptions and experiences formed during the site visits of the accommodations and how those factors could potentially influence the knowledge to be developed. This has been noted in journal entries written during the on-site visits undertaken for data gathering. Even though the journal entries were only discussions with the self, these personal journals helped the researcher to stay as independent and objective as possible, and to remain open to what the data tells and suggest rather than imposing the researcher own views and thoughts on the data.

For instance, one of the early journals describe the researcher's feelings and impressions from a studied accommodation during her first visits. It tells that the researcher felt the place very calm and peaceful, and that the campus accommodating the studied buildings felt very safe and secure. The researcher also noticed that students seemed undisturbed in their activities in their rooms. However, after interviewing the occupants of the same accommodation and re-reading the thoughts scribbled in the personal journal, it instantly occurred to the researcher that being inside the rooms might feel completely different than how it appeared from the outside, and

helped the researcher realize that the occupants actually struggled with using their rooms in an undisturbed manner.

Familiarization and Initial Coding

Once the interviews were transcribed, the researcher further familiarized with the data by reading the transcripts multiple times in order to get a sense of what constitutes the data, what is happening in the data, and what does that mean in the context of the study. This was followed by line-by-line coding of the transcripts, where the content of each line of text or phrase relevant for the studied phenomena was labelled with an Initial Code. Although this task was tedious and time-consuming, it proved to be useful since it prevented the researcher from taking the participants' accounts for granted based on the initial data familiarization. Instead it encouraged the questioning of each assumption, hence ensuring that the researcher remained open to the data, ready to see the nuances in the data. This also helped the researcher to be critical with the data, to generate new areas of enquiry and enabled the identification of the gaps and the missing elements in the data, which was then integrated in the subsequent interviews. Initial Codes in this study, and in general in GT, are relatively simple and short notes referring to an action rather than a topic and more descriptive in nature rather than interpretative. By Initial Codes, the researcher stays close to the data, and when it is adequate preserves the original language of the participants using *In Vivo Codes* (Charmaz, 2006). "Table 40. Initial coding" in the Appendix shows an example of the Initial Codes developed from transcripts.

Memo writing

Initial Coding, once performed on all interview transcripts from one location, was followed by the writing of free style, informal, analytic journals also called Memos in GT. Memos played a significant role in initiating analytic thinking on the Initial Codes, their relationship to each other and to the data. "Table 41. Early memo snippet." shows a fragment of a Memo written after the initial coding of interview data gathered from the first site, Mountain Halls. The letters in brackets are placeholders for participant names to protect their anonymity.

Focus Coding

This style of analysis, exemplified above, allowed the researcher to raise the Initial Codes at higher analytic level by deciding on which Initial Codes make most analytic sense, reveal a pattern or hint toward a gap in the data or in the line of questioning. This process, which can also be conceived as "coding the Initial Codes", paved the way for the development of Focus Codes. While Memos greatly helped the development of Focus Codes, these codes were not explicitly identified in the Memos but on the interview, transcripts, just as in the case of the initial coding.

More specifically, identifying the Focus Codes implied going through the initially coded interview transcripts and re-coding the Initial Codes. Focus Codes incorporate more interpretation of the occupant recounts and of the processes and phenomena that seem to be central to the study than the Initial Codes, hence have a higher analytic value. “Table 42. Focus Coding” shows a fragment of process.

Developing categories

Following the identification and marking of Focus Codes on the interview transcript, the researcher wrote further analytic Memos that investigated the relationships between Focus Codes but also looked at the relationship between Focus Codes and Initial Codes and Initial Codes and the data to see how the newly developed Focus Codes fit the data. This was in line with the constant comparative nature of GT (Charmaz, 2006; Groat & Wang, 2013). “Table 43. Memo snippet” from the Appendix shows an extract of a more developed Memo analytically discussing and interpreting the relationships between the Focus Codes and comparing those to Initial Codes and to the data is presented.

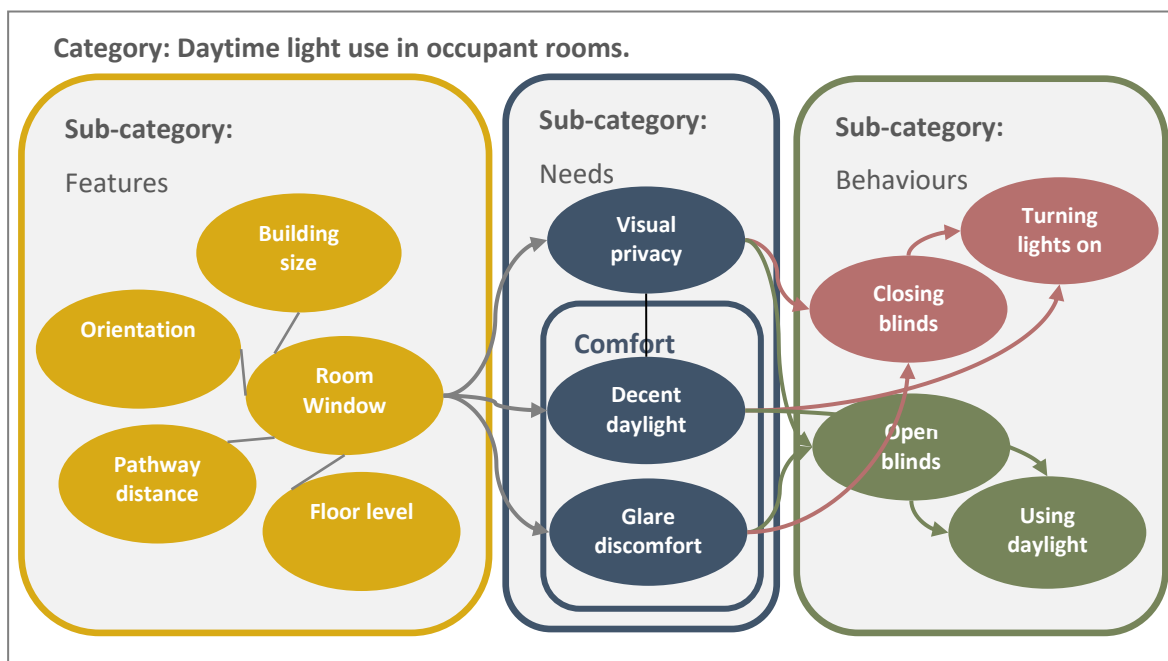


Figure 3. Emerging categories and their relationships based on presented interview snippet and memo.

The constant analytic journal writing process helped further develop the Focus Codes towards nascent Sub-Categories and Categories. At this point clustering also helped the development of Sub-categories and Categories. Clustering is a process aiding and fostering the analysis by creating an image which makes the connections between Sub-categories and Categories more visible. Figure 3. shows the developed Sub-categories, their complex relationship with each other and how all the Sub-categories together support the Category of light use behaviours in student room.

Similar to light use in student rooms, a number of additional Categories have been identified during the analysis, all following a similar pattern and having as Sub-categories a set of specific Features, Occupant Needs and Behaviour. The Categories - each encompassing a phenomenon or set of environmentally significant occupant behaviours (ESB) - were found to be somewhat different based on whether they were concerned with specific interactions with specific elements or features of the sustainable accommodations, also called Detailed affordances (Maier et al., 2009), or with overall interaction with the building as a whole entity, also called High-level affordances (Maier et al., 2009), and delimited the two Main Categories. Finally, these Main Categories structured around the interactions with the sustainable accommodation overall, and the specific interactions with specific elements and features of the sustainable accommodation, with the encompassing Categories and reoccurring patterns of Sub-category relationships, hinted towards the final Theoretical Centrality and Understanding. To aid visualisation, the Theoretical Centrality and the Main Categories with related Categories and Sub-categories underwent clustering resulting in Figure 4. The process of initial coding and focus coding, memo writing, clustering and the development of sub-categories, categories and main categories described above has been performed for each set of interviews and merged across sets of interviews. This means that the interview data collected from the first location has been analysed first and in one effort, followed by similar types of analysis of the interviews from the second, the third and finally the fourth location. This evolving nature of data gathering and data analysis specific for GT enabled the researcher to revisit, refine and extend the tentative categories developed in the first set of data analysis, directing the research questions, the data to be gathered and subsequent analysis in a more relevant direction for the emerging analytic issues. Since the results of the analysis of the last set of interviews echoed the findings of the previously analysed datasets, the interviewing process and the subsequent analysis of the data stopped with the fourth interview set and the 20th interview.

The interview data was further supplemented by diaries provided by the participants. Although the interviews were the primary data source in the present research, diaries on environmentally

affecting actions performed in the accommodations including participant-made photos, site observations and researcher-made photo documentations from site visits consolidated and hence strengthened the study by supporting or complementing parts of the interview data. However, the diaries were not coded independently but were added to the interview transcript as responses and coded in the interview transcript. Given that not all participants provided diaries, the fusion of the diaries with the interview data was performed only in cases where diaries had been provided. In cases where secondary data was not provided by a participant, prompts prepared before the interviews from locations-specific secondary data of co-residing participants, proved helpful in generating rich and valid interview data.

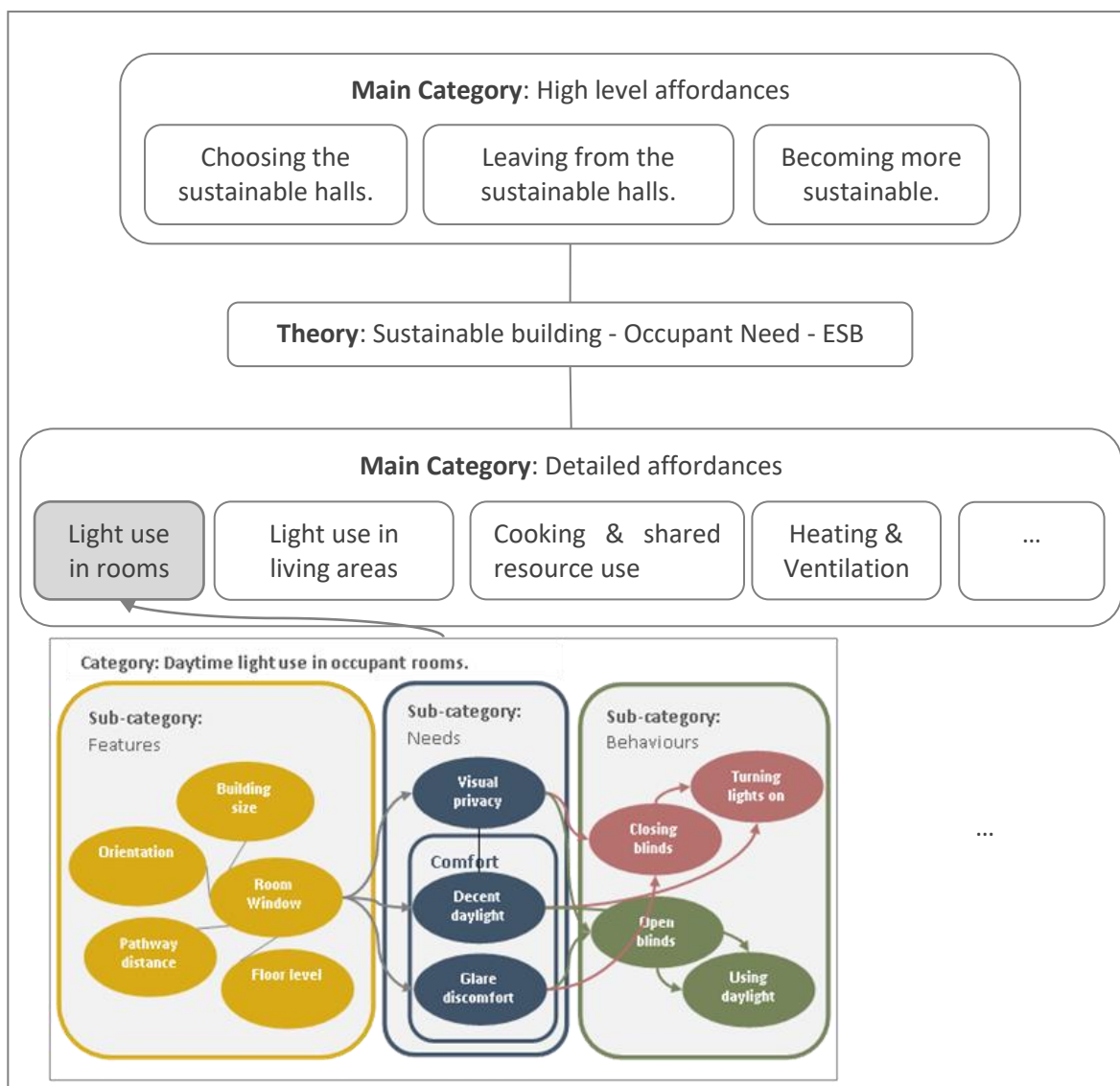


Figure 4. Final clustering.

4.3. Results

The present section presents the results of the analysis of twenty (n=20) face-to-face, in-depth, semi-structured interviews performed with undergraduate and postgraduate students living in four sustainable university accommodations from across the UK. The study investigates how occupants of sustainable accommodations perceive their environmentally relevant behaviour may be swayed or afforded by the physical environment of the building.

The findings cover two major topics developed analytically: high-level affordances and detailed affordances (Maier et al., 2009) of the sustainable accommodations. High level affordances are further divided in expected high-level affordances and perceived high-level affordances. Expected high-level affordances represent occupants' expectations while selecting the accommodations and are of interest for the present study since selecting the sustainable accommodation may be considered the very first environmentally positive act occupants perform in relation to the sustainable accommodations. Perceived high-level affordances (Maier et al., 2009), capture the overall meanings occupants associate to their accommodations which in turn may relate to environmental attitudes and behaviours of occupants. Finally, the section presents extensively findings related to perceived detailed level affordances and highlights how the building via its physical characteristics and features is perceived by occupants to be shaping everyday behaviours and building interactions with an environmentally significant character.

The above concepts will be described and interpreted in detail in the coming sections while also showing how they point towards a newly developed theoretical understanding with which the present section concludes.

4.3.1. High level affordances and sustainable behaviour

4.3.1.1. *Expected high-level affordances and sustainable choice*

The first environmentally sustainable action occupants perform related to sustainable accommodations may be considered the selection of the accommodations. In order to understand how occupants decide to select living in a sustainable accommodation, the study prompted occupants to discuss their reasons of selecting their residences. Their recounts allow extraction of a set of criteria they apply when selecting the accommodations. These criteria may also be considered as the high-level affordances accommodations are expected to offer for making themselves more inviting and appealing to residents. Ultimately, sustainably designed residences with good occupancy rates are also economically sustainable hence the occupant behaviour of selecting the sustainable accommodation is an act that also supports economic sustainability of sustainable design.

Occupant selection criteria of their future accommodations is summarized by the table “Table 4. Selection criteria of sustainable accommodations.” as discussed in the context of each distinct site where data gathering took place. After merging the selection criteria of participants from all studied accommodations, the below final list emerges:

- modern appearance
- novelty
- comfort
- natural lights
- privacy
- safety and security
- proximity to other university buildings
- proximity to public transport
- eco-friendliness
- positive first experience on open day visits

Table 4. Selection criteria of sustainable accommodations.

<p style="text-align: center;">Mountains Halls</p> <ul style="list-style-type: none"> • stylishness • comfort • safety and security • proximity to other university buildings 	<p style="text-align: center;">Pell Park Quarter</p> <ul style="list-style-type: none"> • novelty and modern character • stylishness • safety and security • experience of open days • proximity to other university buildings • proximity of public transport to city centre
<p style="text-align: center;">Daniel Defoe Hall</p> <ul style="list-style-type: none"> • aesthetic qualities • novelty • being the first occupant • natural lights • proximity to other university buildings 	<p style="text-align: center;">Crome Court</p> <ul style="list-style-type: none"> • privacy • novelty • aesthetic qualities • eco-friendly

Since the study did not investigate the hierarchy of these selection criteria, it does not assume which criteria takes precedence over the other. Therefore, the list can be considered only as an enumeration rather than representing any kind of relationships between these criteria. Nevertheless, by considering the number of occurrences of each criterion from the list in the student recounts, an order could be established to suggest popularity of a criterion. However, such an ordered list would have to be verified statistically, using a much larger sample size than the present, qualitative data set provides.

An important aspect the gathered data and the extracted list with expected high-level affordances reveal is that, in search for their new “home”, students very rarely consider the sustainable character of their future accommodations. This is presumably caused by the fact that, most students have no knowledge whatsoever on the sustainability profile of the university residence

they are about to select, presumption also supported by the demographic questionnaire asking students to fill in the energy rating of their halls. Residents' recounts also support the lack of knowledge of sustainability rating of the accommodations at the time of residence selection.

(Sione@MH) "I really didn't know too much, I just knew that, ahm, there are two accommodations and then Mountain Hall is the nicer one I suppose... I didn't realize it was a sustainable accommodation at first, but I suppose it is quite important."

Those few who used the sustainability of the building as a selection criterion have invested time into researching the sustainability aspects of their accommodations and had strong pro-environmental views.

(Marion@CC) "I was obviously looking for the cheapest option to begin with, but when I researched the accommodations, I think Crome Court and another residence I think they were... like ... in general the idea of it being eco-friendly I got interested because I'm interested (as a Sustainability Masters student), so it was like a bit like living in a cool place you know ... I didn't choose this as my second choice or my first choice because the first choice was the cheapest one, but it was not that cheap, but when I got this instead of my first choice, I was instead of changing I was more than happy because it was a good combination."

The fact that future occupants are in general unaware of the sustainable character of the building and that only those with a vested interest in sustainability after doing research may find out about it suggests that the information on sustainability of the building may not be highlighted for future occupants at the time of selection.

Additionally, Marion's account also shows how price is a highly significant selection criterion for future occupants while they are assessing and evaluating potential accommodations. However, none of the studied sustainable accommodations may claim to be the most affordable option. Despite the potentially deterring effect of higher costs, future occupants still mark the sustainable accommodation as one of their top choices. It can be argued that the selection criteria identified in this study are those that prompt occupants to put down the sustainable accommodations as one of their top choices or as their top choice, even if the sustainable accommodations may be more expensive. Therefore, strong support of the selection criteria identified in the study may sustain the success of sustainably designed accommodations.

(Harry@DDH) "... I really wanted to go there because I believe being in a nice environment can help your studies and generally makes you feel better...so... even though it was considerably more expensive than the other ones, I just wanted to see what it would be like..."

Conclusion

The above investigations reveal that student-occupants chose their accommodations based on a variety of selection criteria such as comfort, novelty, aesthetic qualities, safety and security, privacy, proximity to points of interest, natural lights, experience of open day events and sometimes eco-friendliness. These qualities can also be conceptualized as high-level affordances expected from the building by future occupants. It can be hypothesised that where the studied sustainable buildings are perceived by potential occupants to comply with these criteria, they may be inclined to put down the sustainable building as the top choice or one of the top choices. Even if their choice may not be primarily motivated by pro-environmental attitudes, the act of choosing to live in the sustainable accommodation makes the occupants contribute to environmental sustainability since these buildings may have a more resource considerate operation partially due to incorporated technologies and sustainable architectural design features. Additionally, the act of choosing the sustainable accommodation also means revenue for the accommodation which contributes to the economic viability of environmentally aware accommodations. Finally, the identified selection criteria – except the experience of open day events - are concepts akin to high-level affordances and may be workable design brief elements in real-life architectural projects, making the present findings highly relevant for industry as well.

4.3.1.2. *Perceived high-level affordances and sustainable behaviour*

Once occupants move into their new accommodations, they start discovering their new environment and look to validate the selection criteria they applied when selecting the accommodations. Their recounts of living in the accommodations commonly associate their new residence with novelty, comfort, safety, security, and a positive aesthetic appreciation.

(Harry@CC) "... about the building... well I really like it still, I do like the design of it..."

(Marion@CC) "... it was a new accommodation it felt relatively comfortable, the kitchen was very big which was quite comforting and there was a lot of space in the kitchen as well..."

(Suzan@CC) "...there are CCTV everywhere, there is security for 24 hours in plus there is a security point, you cannot access the Hall of the accommodation area, ahm...so yes, I feel safe... if I want to go to my bed, I feel comfortable, there is no one can access there..."

Beyond validating their initial selection criteria, occupants start developing social bonds in their new residences, hence the residence is a place that gains a socialization supportive dimension:

(Andy@PPQ) "... so I just went to different parties (in the hall), made friends, get to know other people, made acquaintances, it was all good, basically, the first week, the first couple of weeks were just about parties..."

(John@MH) "... Socially speaking it was very nice moving into the flat, you could have a kitchen environment where you can sit and chat together, ahm... overall very happy with the accommodation..."

For some occupants, the social ties developed in the building become the primary significance of what being in the building offers to them:

(Suzan@MH) "...So what makes the building important to you, you feel that the kind of people who you live with..."

Some participants while appraising the furnishing of their accommodations associate the accommodation with a sense of home, they feel homey in the sustainable residence:

(Jack@DDH) "...The sort of furnishing is white, white sort of wood which is you know very comforting and nice and that for me is just very homey and nice and very efficient, I like that..."

(Harry@DDH) "...it's all white and minimalistic ... I really like that, I don't really feel the need to cover my walls in lot of things to make me feel like home..."

Interestingly, there are also occupants who perceive their new residence allows them to live a healthier life facilitated by design features such as the green surroundings or stairs.

(Marry@PPQ) "The environment outside is very good like a lot green so you literally like are in a fresh environment every morning, you get to like ... even if you don't want to go outside to do exercise ... you can just run around...so it's very nice"

(Suzan@MH) "...thanks there is no lift because I would get fat..." and "... this is nothing (referring to climbing stairs) ...you just convince yourself that it's good to do some exercise ..."

Being at home in their residence calls about notions of freedom, which was mainly mentioned within the context of discussing about comfort. While for some residents, sense of freedom was reflected in being able to personalize their rooms, or to perform activities freely, for others freedom had the connotation of being free from following common rules and conventions valid in the outside world.

(Wayne@PPQ) "I really do like to have my own space; I work a lot better...if I want to wake up at 3 am and check up and do some work, then I can work then, yeah..."

(Suzan@MH) "Because when I go home, ... ahm... freedom...you don't have any kind of... how do you call this... restriction... exactly... you don't have any kind of restriction... I'm talking about comfortable, when you just wear your pyjama...this kind of comfort.... when you take your shoes off...this kind of comfort."

Privacy remains an important aspect of living in the accommodations just as it was an important criterion for selecting the accommodation in the first place:

(Nadya@MH) "I really-really like to be private; no one can disturb me, that's what I meant..."

Privacy emerges as an even more important factor when the environment does not allow it. In cases where student flats undergo frequent verification by the staff, residents feel their privacy is invaded, and associate the accommodations with an environment that lacks privacy.

(Andy@PPQ) "...Basically they can enter your room any given point in time and I don't really like that...so that's my main let's say concern about the whole accommodation..."

Andy reveals that privacy concerns are powerful enough of a driver for occupants to consider leaving the residences altogether:

(Andy@PPQ) "...So this is an invasion of your privacy... that's quite a big issue, that's one reason why some people who stay here, they don't want to stay here next year..."

This may also mean that in case occupants perceive their privacy is diminished to unacceptable levels, the sustainable accommodation occupancy rate may be reduced. And just as high occupancy rates mean more numerous students living in sustainable accommodations which may

have more moderate impact on resource use and the environment than conventional buildings, lower occupancy rates mean more students living in potentially more resource intensive accommodations with higher environmental impact. The privacy concerns revealed in participant recounts may be less workable in an architectural context since architects do not have agency over how the accommodations are run by the accommodation provider. However, the findings on privacy concerns may be of use for universities and accommodation providers looking to ensure good occupancy rates in sustainable accommodations and may guide them in limiting privacy obtrusive procedures.

Finally, the study reveals environmentally potentially significant associations occupants make with the appearance of the sustainable accommodations. As mentioned in the previous section, “4.3.1.1 Expected high-level affordances and sustainable choice” the novelty and the modern appearance or aesthetics of the building were among the selection criteria of sustainable accommodations. The interviews additionally reveal that novelty and the modern appearance of the building also lead some occupants to believe the building is sustainable. For them novelty and sustainability are strongly associated.

(Jack@DDH) “... Whereas Daniel Defoe Hall is very minimalistic, it’s quite stylish and because it’s so new, it’s also got a very sustainable feel, it feels very progressive...”

This may be significant for sustainable accommodations since the same participant also reports adhering to more sustainable ways of doing due to the “sustainable feel”, after moving into the accommodation.

(Jack@DDH) “...When I was home, I was probably less, how can I put it, environmentally concerned and now that I live in these halls, they look so nice and it’s really fit in the whole sustainable feel, it has definitely influenced me to be more sustainable and to use less power and you know some lights if I don’t know if the battery in my phone isn’t that low like 50% or something than I’ll probably use that for the next day, I won’t want to charge, that sort of stuff...”

This suggests that where occupants perceive the accommodations as novel and modern, they may associate the idea of sustainability with the building, and potentially engage in sustainable behaviours. This finding may be significant in the light of earlier studies that found that knowledge on high pro-environmental profile of a building, may lead visitors to act more sustainably (Khashe et al., 2015). Even more so that all one hundred (n=100) participants in Khashe’s experiment were also students just as the participants in the present study. Therefore, ensuring that occupants perceive the building as novel and modern, and know about the sustainable character of the building, might be important in better supporting occupant choices of

sustainable accommodations, but also in swaying day to day occupant behaviours towards sustainability.

Conclusion

The current section presents occupant perceptions on what the sustainable accommodation affords once they have moved into their new residences. It is found to be common for occupants to evaluate how the buildings fulfil their initial expectations captured in their selection criteria, and this evaluation yields generally positive appreciation of the sustainable accommodations. In addition to evaluating their selection criteria, occupants also start associating new dimensions to the sustainable accommodations. The building becomes a place for socialization where occupants may feel free, at home and healthy. Additionally, the new residents may also start associating the novelty and the modern aesthetic qualities of the accommodations with the concept of sustainability and may engage in sustainable behaviours they did not perform in their previous home. While this likely constitutes a positive contribution of the sustainable accommodation to the sustainability of occupant behaviours, the study also highlights potential detrimental outcomes. Where privacy, commonly expected to be ensured by the accommodation, is diminished significantly, occupants may consider moving out to other, potentially less sustainable accommodations. While this may not have direct effect on the sustainability of the sustainable accommodation, it may have an overall less sustainable outcome if the occupants move to a more resource intensive accommodation, or if due to massive departures, the sustainable accommodation becomes economically unsustainable. While this later finding may be of moderate relevance for the architecture of sustainable accommodations, it may need to be highlighted for universities and other sustainable accommodation providers who are concerned with environmental and economic sustainability of sustainable accommodations.

For providing a one-glimpse overview of the previously presented findings, “Table 5. Selection criteria and high-level affordances” captures the criteria occupants use for selecting the sustainable accommodations also called expected affordances, next to the high-level affordances the building is perceived to provide to occupants, highlighting those affordances that are novel as compared to initial selection criteria and those that were found to be potentially significant for sustainability of occupant behaviours.

Table 5. Selection criteria and high-level affordances

Selection criteria	High-level affordances
<ul style="list-style-type: none"> • comfort • novelty • aesthetics • safety • security • privacy • proximity • lights • exp. of open days • eco-friendliness 	<ul style="list-style-type: none"> • comfort • novelty • aesthetics • safety • security • <u>privacy*</u> • <u>sustainability*</u> • socialization • home • health • freedom

** affordances may relate to sustainability of occupant behaviours*
affordances with bold were not among the selection criteria of occupants

4.3.2. Detailed affordances and sustainable behaviours

4.3.2.1. Light use behaviours

The analysis of occupant interviews reveals light use behaviours as a core category of environmentally significant behaviours performed in the studied sustainable accommodations. The data further suggest the light use behaviours are likely specific to each location in the accommodation, with occupants reasoning differently on how and why they use natural and artificial lights in the room, kitchen and living areas or bathrooms of the accommodations. Therefore, the present section presents light use behaviours by locations of the accommodations.

Light use in rooms

Daylight visual comfort

Occupant interviews reveal preference for natural lights in the room during the day.

(Wayne@PPQ) "... the windows are very large, which is generally a good thing, ... , I face out and that allows to see into the Manchester city sky view, it allows a lot of natural light, and uhmmm, its nice for you as well and its a nice thing to have ... I don't use the (artificial) lights at all until 7 or 8..."

(Jack@DDH) "...I never have the blinds down really because I think it's just so nice to get the sunlight in and just work with that..."

Jack's phrasing "...so nice ... work with that..." conveys that since the lights are perceived by him to be suitable for work, he chooses to use natural lights for his mundane activities (Figure 5). However, for Jack to perceive the room as bright enough for work, the design must cater to his need for enough natural lights.

When design results in rooms where occupants perceive the natural light to be meagre, quite expectedly, they resort to artificial light use, which may be quite intensive as shown by Marion's and Sione's recounts below.

(Marion@CC) "... so if they could make the windows bigger, that way people would use less lights maybe you know because you get up in the morning and start to turn the light ... your lights will be on all day until you sleep the evening ..."

(Sione@MH) "...Being the winter it is overcast most of the time and even when it is sunny my room is often shaded by trees which means it gets quite dark. This means my lights are often turned on..."

This contours a pattern, where the extent to which the designed physical environment is perceived by the occupant to support their need of daylight, may sway sustainability of light use

behaviour. While it can be stated that windows are core features that allow natural light to penetrate into the rooms, other design features such as shading from adjacent structures (or trees) are also identified by occupants as affecting perceived light levels and potentially sustainability of light use behaviour. Furthermore, the participants who identify poor daylight levels in their room and speak of more intensive artificial light use mostly live on the ground floor, while participants who praise light condition seem to be residents of higher floor rooms.

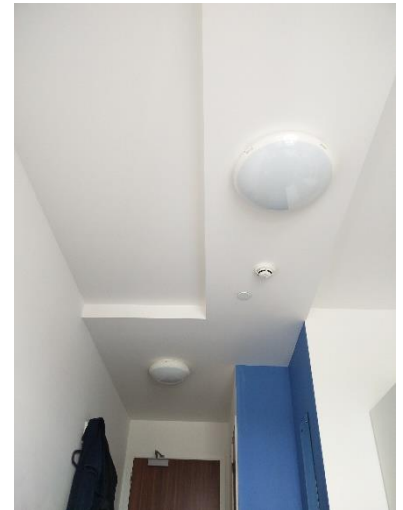


Figure 5. Bright rooms prompting daylight use

Hence floor level may also be a design feature that in tandem with the design of the windows may be influential in how naturally bright rooms are perceived by occupants, potentially affecting sustainability of light use. Additionally, Harry below, further identifies the staggered design of the buildings as a feature that prevents blocking out sunlight and the white walls of the rooms as a feature that helps perceive the rooms as brighter.

(Harry@DDH) "yeah, lots of bright light, I like that it is high rise and the way they staggered the building it's quite nice, they are not all the same level, ahm...in that way that gives you some extra...so it allows light to come in, particularly if you are at the higher blocks, because of this kind of staggered design, which otherwise would be blocked by the other block and you wouldn't have lights coming in, which is really nice" ... "so yeah it's the amount of light in the room makes a difference and make sure the walls are white"

Thus, it can be argued that the extent to which the design of the room windows and adjacent features is perceived to support occupant need of daylight may also be a key aspect in how sustainably occupants use lights during the day.

Visual privacy

The occupant recounts of light use in the rooms surfaced an intriguing phenomenon that may be significant for sustainability of light use and may be very specific to rooms of student accommodations. Some of the residents seem to be very sensitive and protective of their privacy in their rooms given that this is the only space in the accommodation that affords privacy. Hence when they perceive their privacy is diminished, they react by closing the blinds. Although this re-establishes privacy, it has a detrimental effect on the visual comfort of daylight. To regain that, occupants resort to artificial light use during the day.

(John@MH) *"...I think the problem is that, you know, we are living in one room for our whole life, so, for our whole life during these years, so it's not like in a normal house where you wouldn't study or work in your bedroom where you sleep, this is all your personal space in one spot and people can see straight in so you know if I would set in a proper house and someone was walking past and I would sit in the lounge I don't really care too much, I don't know it's probably because I'm right next to the front door, everybody walks past and I don't really like the idea of looking in and see what I'm doing on my computer, it's that close proximity I think... if it was, if it was 10-15 meters off I would be fine, they wouldn't see the computer screen that I'm using something they wouldn't see what I was writing or anything, but at that distance they can see and that, that is annoying but yeah, once I*

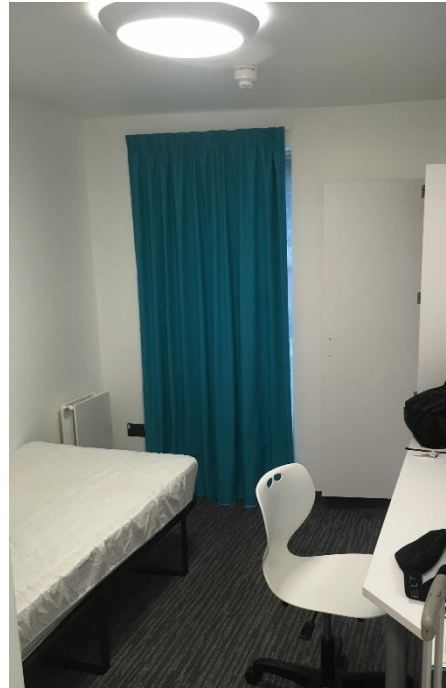


Figure 7. Lights on blinds closed. CC.

left yeah I wouldn't continue that habit of closing the curtains and switch on the light, I don't like it."

Other occupants echo the same experience and have a similarly environmentally taxing behaviour pattern (see Figure 7, Figure 8.)

(Yves@CC) *"...I just use artificial light - if I open the curtain people can see in..."*



Figure 8. Lights on blinds closed. MH.

(Sione@MH) *"yeah, that's why (privacy) I like to keep the blinds half closed because people can see in and ah...sometimes it bothers me like during the night I probably keep it up sometimes just because there are less people out, or during the day, maybe, I do not know, it depends on how I feel I suppose if I feel like having a bit of privacy I keep it down but if I am fine with people seeing me then I keep it up."*

In these cases, the occupants concern with privacy is again fundamentally linked to the windows that allow visibility from and into the rooms. However, the windows are not the only features that are involved with catering for perceived privacy. John first mentions the distance of pathways that are thought to be too near the room windows, then he recollects not having had the same privacy related experience when living on higher floor the preceding year. Hence floor level may also be significant in how occupants perceive the design of the accommodation supports their need for privacy.

(John@MH) "I lived much higher last year and because there was no one able to look in I kept the window much more open, the blinds much more open, and relied less on the lights."

Participants who don't have any privacy concerns also reflect on this phenomenon and find the floor level may be the aspect that enables them to feel private even with the blinds open.

(Harry@DDH) "I've always lived on floors high enough not to be visible from the outside...ahm...where I am now I can still see into a lot of people's flats ...ahm...they can't really see into mine but they can a bit...so we do exchange views a few times...ahm...but we have blinds if people are, if people are bothered by that...ahm...I can see some people may have privacy concerns on the lower levels I haven't been affected by that really... "

Harry above, potentially also due to good perceived privacy in their room, confirms using natural lights for work during the day.

(Harry@DDH) "I'm facing east so I get sun rising in the morning which is really nice and I never have my blinds down during the day which is really nice to get a lot of natural light."

In conclusion, the recounts infer that the way design of the sustainable accommodations is perceived by occupants to support privacy need in the rooms may be significant for the sustainability of light use behaviour in the same spaces.

Discomfort glare

Privacy is not the only occupant need which, if not supported by design, may prompt occupants to close the blinds. When students experience glare discomfort, they also close the blinds and may start using the artificial lights. Closing the blinds may even happen despite the expressed preference of occupants towards working with natural lights, suggesting that glare discomfort may override the benefits of a room that caters for good perceived daylight levels.

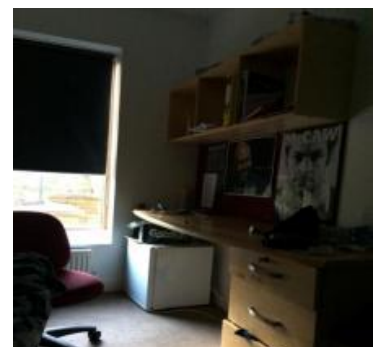


Figure 9. Blinds closed due to glare.

(Nadya@MH) "... it is with a reason (that I don't use the daylight but the artificial light) and it's because I think it hurts my eyes ... that was the main reason ...and that's why I am using the lights but then, you know, using the lights when it's daylight was not good..."

(Sione@MH) "I prefer to have the blinds open because I just like the natural light because natural lights are better for helping me see things but I kind of have work next to the window because that's where my desk is, ahm so it is kind of a, if its cloudy it's alright, I can open up the window and it's just fine, but if there's the sun because after noon it

comes right down, it is harder to see the screen... most of the time the blinds are half way down just because it stops the sun coming in..."

Sione's case reveals that besides the window which is the central design feature that provisions daylight into the room, other components of the design such as furniture arrangement – the desk next to the window, may jointly be related to how the occupants perceive the design supports their need for visual comfort and eventually sway the sustainability of their light use behaviours in the rooms. Additionally, the use of the blackout blinds to control glare (Figure 9) further indicates that there are no other design features integrated into the sustainable accommodation that may ensure glare control without having to close off.

Thermal comfort - solar heat gain

Finally, thermal comfort of occupants when impacted by solar heat gains further drove occupants to adopt the same mechanism of closing off with blinds and using artificial light during the day.

(Michael@PPQ) "...and the Sun comes straight to my window in the morning and I actually had an experience, was it two days ago, the radiator was off in my room, the sun came through my window and because of it I was trapped behind the curtain as soon as I pulled the curtain all the heat came in my room at I was boiling like that and it was like you could just stand in the window and it was just like, yeah...it was boiling...you could feel the windows were boiling hot..."

(Nadya@MH) "... it is with a reason (that I don't use the daylight but the artificial light) and it's because I think it hurts my eyes ... that was the main reason and sometimes it was too hot so I end up sweating so I just rather close the curtain and just open the windows until the night will come and that's why I am using the lights but then, you know, using the lights when it's daylight was not good..."

Conclusion

Participant recounts of light use behaviour suggest that occupants of sustainable accommodations seem to use light more sustainably when they perceive the design of the accommodations support their needs. Perceived natural brightness of their rooms seems to directly relate to how much occupants rely on natural lights or artificial light, hence impacting environmental sustainability of their actions. Additionally, very specifically to rooms of sustainable accommodations, perceived design support for visual privacy emerges as a code that may impact sustainability of light use during the day since occupants who don't find their room offers privacy close the blinds and start using artificial lights. Finally, glare discomfort and thermal comfort (as impacted by solar gains) constitute further occupant needs that designs may need to cater for in order to promote more sustainable light use behaviour.

This suggests that in order to promote sustainable light use patterns by design, the design features of sustainable accommodations may have to be considered with occupant need focused lenses. While the room windows seem to be central design features that allow the interchange of light between occupant rooms, occupants and the exterior, the interview snippets included in this section suggest that multiple design features may together contribute to how far occupants perceive the design of the accommodations support their needs.

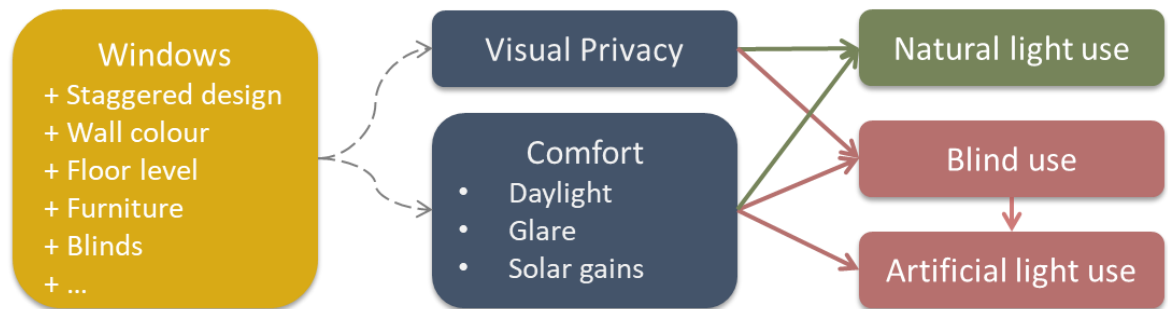


Figure 11. Occupant light use behaviours in the rooms

Figure 11. represents visually the conceptual understanding built based on the collected occupant data. It represents the way Windows as core design features grouped with adjacent design features may be perceived to be supportive of occupant needs of Visual Privacy and Comfort. Here Comfort incorporates visual comfort of daylight, discomfort glare and thermal comfort as influenced by solar gains. Finally, the red arrows represent occupants perceiving their needs as not well-supported by design and their likely less-sustainable behaviours via artificial light use. Conversely, the green arrows are path taken by occupants when their need are perceived to be supported by the design features of the sustainable accommodations, and they decide to use natural lights during the day.

Light use in the bathrooms

Comfort and Ease of use

The bathrooms of the studied accommodations are integrated within occupants private living quarters and usually do not have windows towards the exterior, artificial lights being the sole source of light. While this is already more energy intensive than using natural lights, occupants also raised concerns regarding the controls of the artificial lights, potentially increasing artificial light use.



Figure 12. Bathroom lights on

(Harry@DDH) "Position the switches in a weird way in my mind, so if the door opens this way the light switch isn't there, the light switch is

behind the door ... it's really annoying to go around...really annoying... again, little things, I know but..."

The above lines illustrate participants dislike towards the light switch of the bathroom and even though they acknowledge that it is a relatively minor issue, they repeatedly stress on its uncomfortable nature. Furthermore, the participant reveals that the bathroom is equipped with a secondary light source above the mirror, which is well appreciated since it makes the uncomfortable actions of going around the door and finding the light switch unnecessary. However, the additional light source is left on continuously by some occupants so they can enjoy the comfort of having the lights on when entering the space, comfort which is cumbersome to achieve using the main bathroom light switch.

(Harry@DDH) "... inside the bathroom there is also an additional light above the mirror, which is nice so you don't have to... (go around the door and find the switch) ... so a lot of people they just use the lights above the mirror, ahm, which is nice but I know a few people that just leave that mirror light on all the time just for when they go in there have lights..."

Harry also tries to identify reasons behind the energy wasteful light use in the bathrooms, such as being lazy, forgetful or intentionally leaving the lights on to increase comfort.

(Harry@DDH) "So people get lazy when they are in a space and so they forget the light on, or they just leave it on intentionally... (just for when they go in there have lights...)"

Leaving bathroom lights on is echoed by other occupants as well. For instance, Sione mentions that he used to leave the lights on in the bathroom by mistake, probably referring to the fact that he forgets to turn it off when he leaves the bathroom.

(Sione@MH) "During the night my lights are most of the time all turned off, however, sometimes I leave the bathroom light on by mistake overnight."

Felix, on the other hand, keeps bathroom lights on intentionally during the night in order to support his comfort guide lights can afford.

(Felix@MH) "...I will leave my toilets lamp on because if I want to go to the toilet at the midnight all you need is, you know, some guidance lights... so I will turn it on and it is energy saving as well..."

Felix's recount suggests that this particular choice of action of leaving some bathroom lights on for longer periods even when the space is not used might also have something to do with the belief that bathroom lights are less intensive and therefore more efficient. Harry's recount also mentions mirror lights that are usually less intensive than main lights. Hence this might be an occurrence of psychological discounting since occupants use devices that they believe are less

resource intensive therefore it is acceptable to leave them on even when the space is not used. Still, the primary trigger seems to be the satisfaction of comfort need: either of not having to do the effort of finding the right switch either of having lights readily available when waking up during the night.

While participants acknowledge the energy wasteful character of the action in discussion and express dissatisfaction towards it, they confirm that the major reason behind the energy intensive behaviour is the uncomfortable location and the confusing functioning of the main light switch, with which the participant cannot become familiar, not even after half a year.

(Harry@DDH) "...ahm, which (people leaving mirror light on continuously) annoys me you are wasting all that power but it's probably to do with the fact that the switch is a mile away... " and

(Harry@DDH) "... the way the switches have been laid ... is quite noisy, you have the room and the bathroom on same panel which is why the light is switches there, so when you come in through the door it makes sense to have the lights there ... when you enter the bathroom you have the switch behind the door, and the kind of, in my mind they have it wrong, I always end up switching the bathroom light on when I want the room light on because, so we have two panel, two switch panel there, let's say this is the door to my room than this is my window over my bed, we have one light that shines above the bed and then one light that just shines above the door of the bathroom, yeah, I don't know why these two lights or the lights on the switch on the left so towards the door that turns on in the room which in my mind that should turn on in the bathroom because specially I'm thinking ok so this button is closest to the door where I'm now but it should be for the room closest the door and then for the area further away... the switches further away. I live here since September 2014 and I still get the switches mixed up every time, I don't know how but then I guess in their minds it must have made sense to ok, we are reaching them from the door than it would make sense to push which is closest to the, slightly closer with a centimetre to the door but for some reason it's just doesn't make sense to me..."

Besides expressing the uncomfortable location and the perceived lack of logic or ease of use of the main bathroom light switch and linking that to the unsustainable light use in the bathrooms, Harry parallels his views with that of designers and recognizes that there must be a gap between his way of thinking and the architects way of thinking on the use of the bathroom light switch. Thus, Harry identifies the reason of light misuse in a potential mismatch between the architect's mental models on how the bathroom lights ought to be used and the occupant's mental models on how the bathroom light switch can be used.

In conclusion, sustainability of occupants' light use in the bathroom seems to be swayed by how comfortable and easy to use they perceive the light controls to be. Additionally, the comfort need

of having minimal light level ensured by the environment during the night also seems to contribute to using lights more intensively.

Control

Occupants also discuss automatic light controls that are becoming increasingly common in the bathrooms of sustainable accommodations. Since these devices turn off lights when a space is vacated, these may be considered very useful in reducing light energy waste caused by lights that have been forgotten on. However, these devices remove occupant agency and may not be in line with their preferences (Figure 12, Figure 13).

(Michael@PPQ) "...There have been issues with the sensors though in many of the bathrooms in the accommodation these sensors have different time zones so my bathroom light will take up to 10 minutes to turn off... I think manual control in the bathroom would be probably preferable for most, quite a lot of people..."

Additionally, since the lights turn off after no movement is detected for a given period of time, they also generate a fix amount of waste each time the spaces are used, and the occupants don't have any way to turn off lights manually if they wish to do so.



Figure 13. Bathroom lights on

(Marry@PPQ) "...sometimes it takes really long to go off like I think that's because of the movement of the steam or whatever and it takes really long to go off and I sometimes I am like please go off faster because I'm not using it so..."

Hence, enabling occupants to control the lights may further reduce artificial light use in bathrooms.

Conclusion

The recount of light use patterns in bathrooms of student accommodations suggest that when occupants perceive the light system including its controls, is supportive of their needs for comfort, control and ease of use, light use behaviours may be more sustainable as shown by the green arrows on Figure 14. Conversely, when these needs are not well-supported by their environment, the light use pattern seem to be more energy intensive and therefore less sustainable, indicated by the red arrows on Figure 14.

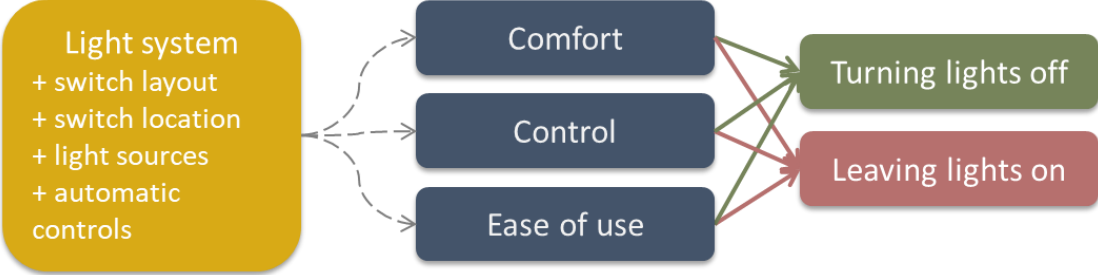


Figure 14. Light use in the bathrooms

Light use in kitchen and living areas

Visual comfort of daylight

In the context of kitchens and living rooms, residents express satisfaction with the large windows that allow views onto the surrounding areas and naturally bright up the space.

(Jack@DDH) "It's two walls that literally just glass and that it is just lovely honestly I mean you can just see over London; really nice view and the sun light illuminates the whole room."

(Jaden@DDH) "... they have large openings, windows everywhere, which makes you think why do we need to be with the lights on so that is a big influence I think again ..., so you know you got the sun coming in all the time so that makes me not want to turn the lights on because there is no need..."

In addition to the satisfaction good natural light levels provide, the above participant recounts shows how the perceived comfort of daylight in the communal areas, just as in the rooms as presented in the above section "Light use in rooms", might lead to reduced artificial light use throughout daylight hours.

Controlling lights

Although the kitchens and living rooms are equipped with generous glass outer walls and are perceived to be sufficiently bright to enable occupants to comfortably use the space by relying on daylight only, occupant's recounts from the same accommodation further reveal that the same areas are always lit artificially since motion sensors turn on lights on the slightest movement. The lack of manual controls removes residents' option and agency over turning the lights off when they don't need it, as well illustrated by Figure 15. Occupants can well-identify the redundant use of artificial light and the waste it may generate.

(Harry@DDH) "I don't usually turn the light on because by the time I wake up there is usually enough natural light so I don't have my lights turned on, ahm...I walk out into the kitchen and the lights turn on unnecessarily ..." and "...it makes no sense and it is really annoying because I think that the idea was that it's energy efficient..."

(Jaden@DDH) "...one thing we wouldn't have and could save a lot of energy is if the automatic lights in the building, the light would be on during the day just because



Figure 15. Automatic lights on in bright kitchen during the day

it's senses our movement when that's not necessary... there are huge windows all around our kitchen enough natural light are coming in yet the lights are still on because we don't have the ability to turn it off..."

Occupants formulate additional critiques to movement sensor-based light controls in the communal areas even when those were paired with manual controls as well. Some participants believe that although sensors could prevent unnecessary light use due to lights left on, it also has the shortcoming of encouraging residents not to actively pay attention to turning off the lights when spaces are vacated.

(John@MH) "...It's quite two fold, because I guess it means that ...it's not lights running all night, but at the same time leaves you not feeling like you need to switch off the lights physically because they will go off later ...it's strange but because that you just don't bother and no one does either ...just leave them on..."

Occupant responsibility of switching lights off although might seem unimportant from a practical perspective, since movement sensor-controlled lights will turn off after the space is vacated. However, occupants also mention that although the lights turn off automatically in the kitchens and living areas when there is no movement in the space, they require a significantly longer time span for switching off. This also means that not turning them off immediately after vacating the living and kitchen areas still results in unnecessary energy consumption:

(Harry@DDH) "...I'm not sure how long but at least half an hour to turn off.'

(Marion@CC) "...the kitchen lights are also controlled automatically but they are for longer duration so when you cook they take longer to turn off so maybe they take half an hour - 45 minutes to turn off..."

Additionally, not all the spaces in the accommodations are equipped with movement sensor controlled lights. While the communal areas of the accommodations make use of automatic movement sensors for controlling lights, the rooms and some of the bathrooms only have manual light controls. However, if occupants start relying on automatic controls in some spaces and develop the habit of not turning off lights when vacating those spaces, the question arises whether that habit may also spread to other spaces where automatic light controls are missing, potentially leading to more energy waste.

In contrast with the above case, in the accommodations where the automatic light system is complemented with manual controls, occupants may be more accepting and may feel more comfortable.

(Wayne@PPQ) "...The lights ... are automatic, ... there is a light switch as well...when you forget to turn on/off the light they will go off automatically, it is no big deal because after it will go off.I think it's useful, it's not intrusive, it doesn't do it intrusively..."

The above examples show that the dual light controls allow occupants to appreciate the beneficial effect of light turning off automatically when the room is vacated while they also enjoy the benefits of controlling it manually in case they wish to.

In conclusion, the occupant recounts suggest that lack of control over the lights may be detrimental to occupant satisfaction and could also lead to increased artificial light use during the day even when natural light is abundant. While automatic lights may alleviate the cognitive effort of having to remember to turn off lights once a space is vacated, it only seems to be appreciated by occupants when some form of occupant control accompanies automatic controls in the design of the sustainable accommodations.

Comfort of activity-matching lights in kitchens and living rooms

Additionally, it seems that having only automatic controlled lights without manual control is not endorsed by residents neither during the day but nor during the evening. This is especially so when the lack of manual control over the movement sensed lights creates an uncomfortable environment for performing the desired activities in the space.



Figure 16. Group dinner in the kitchen.

Eventually, lack of comfort leads residents to restore their comfort by circumventing the system. The below recount reflects occupants' views that providing manual control and more options over the light and its intensity would lead to more sustainable nocturnal light use behaviours in the communal areas of the accommodations.

(Jack@DDH) "...In our communal areas we have lights that turn on based on movement and in my opinion, it is a bit stupid...when it comes to watching a film or something you have to sort of shut in all over the sensors so you keep it dark because there is just no switch which is very odd....so if they removed



Figure 17. Kitchen as setting of evening activities.

"In this kitchen, I had so many wonderful experiences with my lovely flatmates, Kate's surprise birthday party, Halloween party, drunk night, so much fun. In the kitchen we have a good TV and sofa, we spend leisure time in the kitchen and chatting, it is a great place." (Felix@MH)

them in say switches it would be far more sustainable because it would subsequently save more energy...” and “...sometimes it is not necessary and it’s nice to be able to switch the lights off and chill out in the dark, as weird as it sounds.”

(Harry@DDH) “...in the evenings as well if the lights could turn off than we would be able to see all the nightlights of London... but we have to cover the sensor if we want to do that.”

Although the circumventing action seems more sustainable and energy efficient than the inaction of leaving the lights on, anecdotal evidence suggests that it also carries safety concerns when the tape is left on the sensor and a person stumbles over objects lying around in the dark room. Furthermore, students report subverting the system only in cases when the comfortable enactment of their activities is hindered by the overly strong artificial lights. In other cases, when occupants do not want to use the living rooms for activities that necessitate lower light levels (Figure 16, Figure 17) , but for something more mundane, such as preparing dinner or just being in the space, they don’t seem to perceive their comfort level reduced and also don’t recount of any sensor circumventing practices. This also applies for daytime activities. Despite their acknowledgment of the artificial lights being wasteful during the day, occupants do not recount of diminished comfort nor do they take action to cover the motion sensors.

(Harry@DDH) “... if you walk in there and you do want to cook something because it comes on instantly and you know the lights are well placed and it’s a nice big kitchen you can cook whatever you want ...all the appliances there are great ...” and “... let’s say you are going in, in the evening to get some water or even during the day, even during the day there is a lot of light coming in and then when you are going into the kitchen for some water all the four lights in our kitchen turn on...”

Figure 15. also argues that during the day occupants do not resort to taping the sensors and the artificial lights in the kitchen stay on even on bright days.

This suggests that the driver of the sustainability supportive behaviour of sensor taping to turn lights off may be comfort, more specifically how occupants perceive the space allows comfortable enactment of previously mentioned activities. When the space does not allow activity specific comfortable light levels, light use is more unsustainable since lights are on unnecessarily and unwantedly. Conversely, when occupants take action to re-establish their comfort, light use becomes more sustainable. That is, the comfort need supportive quality of the design seems to be a key to how sustainably the artificial lights are used. Although sensor-based light controls are increasingly common in sustainable accommodations, their usage does not unequivocally serve sustainability or occupant comfort. The contention of the study is that sustainable light systems

should ensure comfortable enactment of activities while operating sustainably and without necessitating potentially hazardous system circumventions that ensure comfort.

Conclusion

Occupant recounts reveal that kitchen and living areas of the accommodations are stages for a multitude of activities spreading across the day and night. During the day, where occupants perceive the space to provide comfortable levels of daylight, they are likely to rely on natural lights rather than artificial lights, making use more sustainable. However, design that deny occupants control over the lights may prevent sustainable light use while leading to occupant dissatisfaction and discomfort. Furthermore, common night-time social activities performed in the space also necessitate reduced light levels. Where occupants perceive their comfort is significantly diminished by the design of the light system, they take circumventing measures that

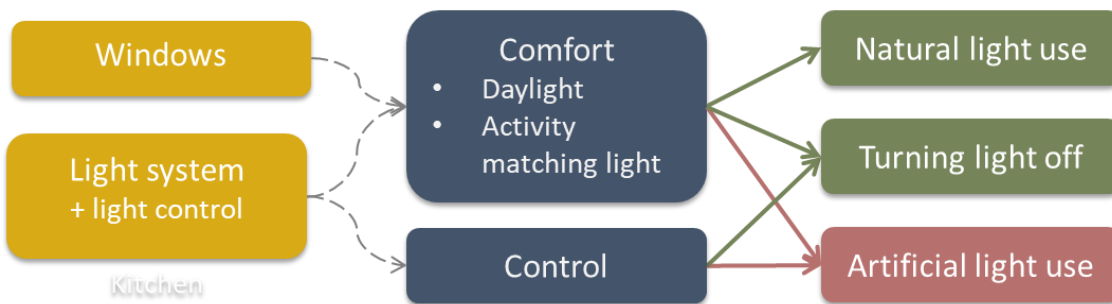


Figure 18. Occupant light use behaviour in kitchen and living areas

have a direct impact on energy use and may also be hazardous. Hence, sustainability of occupant light use behaviour seems to be related to how far occupants perceive the kitchen and living areas cater for their needs such as visual comfort of daylight, control, and comfort of activity matching light levels. Figure 18. plots the relationships between design features of the accommodations, the occupant perceptions of supported or unsupported needs and the ensuing environmentally relevant light use behaviours.

4.3.2.2. Heating and ventilation practices

Heating and ventilation practices emerge as a core category of environmentally significant behaviours performed in the studied sustainable accommodations. This section covers the practices that are performed in the rooms of the accommodations, where the occupant interviews generated the most relevant data. Furthermore, the heating and ventilation practices appear intertwined in occupant recounts since windows are often also used to regulate temperature and airing the rooms has implications on temperature, therefore will be discussed together within present section.

Heating, cooling and ventilation in occupant rooms

Thermal comfort

Occupant recounts suggests that heating and ventilation behaviours seem to be resulting from how occupants perceive their environment complies with their thermal comfort needs. Not too unexpectedly, the most common pattern is that when occupants perceive their rooms as cold they turn on the radiators in order to re-establish their thermal comfort, inevitably increasing energy use.

(Mary@PPQ) "...when I feel it's very cold then I just close the window and I put it(radiator) on..."

(Jack@DDH) "... no point getting really hot in your room but if it's particularly cold than it(radiator) responds quickly and it's good..."

However, paradoxically occupants may also be heavily using radiators when their thermal comfort is diminished from the other side of the thermal spectrum. Rooms perceived overly hot, besides reducing occupants' thermal comfort, might also lead to radiator overuse practices in colder periods and as such constitute unsustainable heating behaviours. More specifically, the interviews reveal that when the radiators heat up the room too suddenly or the rooms are too hot, occupants' experience thermal discomfort and in an attempt to restore that they open the window to cool the room.

(Sione@DDH) "... if it is too warm you don't really think about it you just open the window"

The issue is not that occupants regulate the temperature by opening the windows. The problem is that occupants also leave the radiator running while the window is open to maintain a desirable temperature. When prompting on the reasons why occupants leave the window open while the heater is on, the answer is the following:

(Susan@MH) "...yes...it's because your room is getting too hot sometimes..."

(Nadya@MH) "...it's because in my mind if I close the window, I would be suffocated..."

This unsustainable way of maintaining thermal comfort in the rooms might have turned into a widespread pattern since it is mentioned by several respondents.

(Felix@MH) "...The temperature in the room is very extreme, if you turn on the heater you cannot feel anything unless you turn it to a maximum, but it will be very hot if you do that. So normally, I will just open my windows while turning it on, and I will shut it down when I go to bed, otherwise I will be very hot..."

(Yves@CC) "...It's warm - I use it at minimum but still too warm - depends on the time - I use it at level 1...cool by remove clothing, open the window, sometimes heat stays on..."

The phenomena of heating and ventilating simultaneously may be a highly energy wasteful pattern from a sustainability perspective especially that occupants often mention thermal discomfort caused by high temperatures experienced in their rooms.

(Andy@PPQ) "... Sometimes it (the room) gets too hot ..."

(John@MH) "... One of the main issues is probably the heat, it gets very warm, especially during the night, it can be quite difficult to sleep ..."

High temperatures in sustainable buildings are a somewhat known phenomenon. While it can originate from various reasons, it is commonly believed to occur when the heating is not properly calibrated or the building is not equipped with adequate ventilation. The present study finds an additional potential explanation. It seems that occupants who experience thermal discomfort of overly hot rooms reside on the upper levels of the accommodations while occupants who moved to lower floors of the accommodations are satisfied with the thermal environment of their rooms and report to experience thermal comfort. This suggests that there might be a link between floor level and thermal discomfort of overly hot rooms and that occupants on upper floors may be more likely to experience their rooms as too hot. For instance, John here below compares his previous thermal comfort experiences while living on upper floors to his present experience from the ground floor of the same accommodation:

(John@MH) "... (On upper floors) It gets very warm, especially during the night; it can be quite difficult to sleep..." and "... whereas now I am on the ground floor – (the temperature) - that's not too bad..."

In conclusion, occupant recounts suggest that the sustainability of heating practices may be related to how occupants perceive their physical environment support their thermal comfort needs. When the rooms are perceived by occupants as too cold or too hot it is likely they will try to regain their thermal comfort by behaviours that are energy intensive and as such detrimental to sustainability. While starting radiators is a common practice to heat up rooms perceived as too cold, opening the windows while the heating is on seems to be a common practice to mitigate overheated rooms in cold periods. The latter is of major concern due to prevalence of rooms perceived as too hot in sustainable accommodations and in the view of this study may deny benefits of efforts invested in creating efficient thermal envelopes specific to sustainable building and thus undermine the very sustainability of these accommodations.

Ease of use of heating controls

An additional explanation to unsustainable heating practices may be that users struggle with the control mechanisms available to them.

(Zia@CC) "...The heater is a bit confusing - level 5 it is too much, but on level 3 and 4 it's not enough..."

(Michael@PPQ) "...the thermostat controls don't work because if I turn it on at level 1 it will go to level 5 on all numbers so I only have to turn it on for 5 to 10 minutes to heat the room and that's enough for the entire night...so it gets hot very quickly..."

Some occupants seem to have minimal interactions with heat controls, and they rely on a default setting.

(Jill@CC) "... Heating is always on and always on maximum ..."

(Mary@PPQ) "... yeah, and that is (the room very hot) because of the heating, because the heating is always, I mean it was always set about 5..."

Jack's recount below shows how newcomers come in contact with the controls of the heating systems in sustainable accommodations. His case underlines not only the potential implications of controls that are not clearly intelligible on occupant satisfaction but also on occupant health and well-being.

(Jack@DDH) "...well the temperature, ah...for the first month I didn't really know how to use the ahm...what's it called, the radiators because I never had to do at home because my parents had a thermostat thing, so it was cold (smile) and I got ill as the results ... but lately, because I do know now, you pick these things up, it's been fine..."

Finally, in some fortunate cases the interaction with the radiator seems to be smooth:

(John@MH) "...I mean the radiator is just a box standard, in the bedrooms so you can turn them on and off, it's easy..."

All-in-all, the accounts above suggest that perceived ease of use of heating controls may be significant for the sustainability of heating practices but also for occupant well-being and health. While some occupants may adapt to the control system and learn to use those to fit their needs, others may not invest the effort and use the radiators at a default and potentially highly energy demanding setting. Therefore, design of sustainable accommodations may need to become more aware of ease of use aspects of heating controls in occupant rooms in order to support a wider range of occupants in interacting sustainably with the heating systems available to them.

Comfort of good air quality

Similarly, to the perceived thermal environment, occupants report experiencing different air qualities in their rooms. Some occupants are satisfied with the perceived air quality.

(Marion@CC) "...you have fresh air coming in and out which keeps it quite ventilated which is good so it's quite fresh I would say. Yeah that's ... so far so good "



Figure 19. Trickle vents on windows. DDH.

Occupant satisfaction with air quality is sometimes supported by the trickle vents (Figure 19.) installed on the windows ensuring a constant stream of fresh air:

(Jack@DDH) "...The air quality is really good because it's coming straight through under the window and it's right where you sleep as well..."

(Harry@DDH) "... Yeah, that's been really good, ahm...the air, we have vents in our room, that's on the window, on the lower half of the window... it does always bring in fresh air...."

However, there were also participants dissatisfied with the air quality in their rooms.

(Yves@CC) "...the air is not fresh... "

Often occupants dissatisfied with the air quality in their rooms also enumerated obstacles to airing their room properly, such as the fixed louvers in front of the windows.

(John@MH) "...another slightly annoying feature is that when you open the window there are grills so that means it's very difficult for the wind to come in and cool the room down... "

Others felt that the design of the building which was described as "a box" due to its perceived air tightness, could be responsible for the experienced bad air quality.

(Susan@MH) "...No, fresh air, no... you cannot have fresh air as I mentioned to you before this kind of building it seems they keep the heat in... so when you go outside you noticed that there is a huge difference, yes, it's like a box so if you go outside it is total different..."

While perceived air quality may seem only relevant for ventilation practices, it may also be linked to sustainability of heating practices. It can be theorised that in rooms where air quality is perceived as less good occupants may resort more frequently to ventilating the rooms by opening the windows, which may also result in heating energy waste. The occupant interviews provide

data that underlines this assumption and suggests that indeed heating with open windows may sometimes be triggered by occupants perceiving the air as less fresh.

(John@MH) "...I want to have fresh air coming in so let my window a little bit open just for the ventilation and then turn the radiator on..."

(Marion@CC) "...I usually open the window few times a day just to get some fresh air in. I feel the self-regulating vent doesn't really always do its job, so the room feels a bit non-airy and stuffy. I keep the heating on to make sure the room doesn't get too cold and it stays warm, well at least in the colder period"

Jack's recount below provides further ground for assuming that perceived air quality may be related to sustainability of heating practices. In this case the occupant reports good air quality and turns radiators off when opening the window.

(Jack@DDH) "...The air quality is really good because it's coming straight through under the window and it's right where you sleep as well... if I'm hot I turn the radiator off and then I open the window..."

Jack's behaviour may be considered aimed at reducing temperature in the room which may be a one off, quick action, and may have a moderate energy toll. On the other hand, John's action is aimed at ensuring good air quality constantly, which may be a continuous situation of windows kept open while heating is on hypothetically resulting in significant energy waste.

Hence, it can be theorized that *comfort* of perceived good air quality allowed by the design of sustainable accommodation, may be pivotal in how sustainably students act when trying to achieve good ventilation and thermal comfort in their rooms. When the perceived air quality is good, occupants may open the windows briefly to decrease temperature in the room. In contrast, in environments where students feel the air is still, "suffocating" as some phrase it, they may keep the windows open even when they are using the radiators also generating energy waste.

Ease of use of ventilation devices

While the ventilation devices were perceived positively in providing fresh air, the less straightforward control over these devices raised some concerns from residents. Some participants have difficulties operating the trickle vents:



Figure 20. Trickle vents in DDH.

(Jack@DDH) "... In everyone's' room we have this sort of like grill sort of thing under the window and I only just recently found what that was, because it kept feeling a breeze even though the temperature is really low so I thought I am getting very cold but can't actually pull it off and close it ..." and Figure 20.

Others may not even know of their existence, despite the presence of a trickle vents on the window (see Figure 21).

Interviewer: "I was thinking is there a ventilation device, ventilation system on the windows?"

(Marion@CC) "No, nothing, you have to open the windows."



Figure 21. Trickle vents in CC. Closed and Opened.

The sustainability impact of occupants not using trickle vents or missing correct use may be less apparent. However, considering that trickle vents are intended to keep the air fresh while minimizing heat loss, and occupants may use the windows to get fresh air instead of using trickle vents since they don't recognize how to use the vents, may result in significantly higher heat waste. Hence the extent to which the ventilation devices allow ease of use to occupants may be significant in how sustainably occupants will perform their ventilation practices.

Conclusion

Occupant recounts disclose that heating and ventilation practices may be intertwined, and their sustainability may be related to how occupants perceive the accommodations support their need for thermal comfort and good perceived air quality. Where the design of the accommodation results in environments that hardly afford occupant comfort, resident heating and ventilation behaviour may be more energy intensive or even energy wasteful in the case of heating next to windows kept open.

Additionally, perceived ease of use of heating and ventilation devices may also relate to sustainability of occupant behaviours. Recounts reveal that where use of a heating device is cumbersome or unclear, occupants may use it at the highest setting constituting significant overuse. Furthermore, overuse may lead to overheated spaces potentially prompting occupants to open the windows causing heating energy waste. Finally, where ventilation devices, trickle vents in this case, do not afford ease of use or may be unidentifiable to occupants, they may open the windows to get fresh air or to moderate temperatures, which is considered to have a higher heating energy toll than using trickle vents correctly.

The relationships between heating and ventilation devices, the occupant needs they may have to support to aid sustainable use, and the resulting sustainable or unsustainable behaviours are summarized in the below image (Figure 22.).

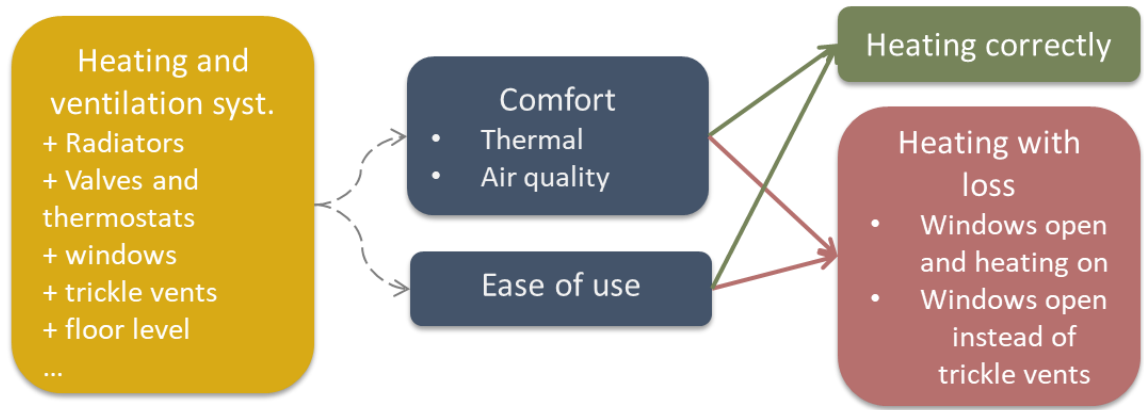


Figure 22. Heating and ventilation behaviours in rooms.

4.3.2.3. *Cooking and shared resource use*

Using the kitchen for cooking individually or in socially in groups, is revealed as a common practice within the accommodations. This may be environmentally significant since the more occupants decide to prepare their meals in the kitchens, the less ready-made food they may order and the less packaging, be it paper, cardboard or plastic they may pile up not to mention the environmental cost of the home delivery process. Cooking socially may also constitute an environmentally beneficial patterns as it may imply more efficient resource use via energy for cooking and lighting shared by the group. Therefore, this section presents the results related to kitchen use and cooking in sustainable student accommodations.

Comfort

Residents of the studied sustainable university accommodations share appreciation towards the kitchens available to them. They highlight the stunning views the large kitchen windows afford during the day and night, the natural brightness of the kitchens, the well-placed artificial lights and the excellent equipment. All these together, the view,



Figure 23. Comfortable kitchen. DDH

the visual comfort of daylight, the comfort of appliances perceived as fit for the activity make the kitchens an attractive place for spending time in and potentially cooking, individually or in group (Figure 23).

(Jack@DDH) "...it's really nice, lovely, really nice kitchen space... it is almost like two walls facing out are just windows, literally just glass and the sun light illuminates the whole room and honestly you walk in there and you can see all across London you can see the London Eye in the distance and the Shard really nice view and even at night is really nice, you can see the sunset ...and you know when it comes to cooking we all kind of thought this is really nice ...the lights are well placed it comes on instantly and it's a nice big kitchen you can cook whatever you want ...all the appliances there are great. So good place for the day honestly, it's great. "

(Wayne@PPQ) "...interesting, we used to cook together, ... one day a person would cook, the next day someone else would cook..."

Occupants also highlight some of the shortcomings of kitchen and living areas that may reduce their comfort. The thermal comfort concerns are the first one mentioned:

(Marion@CC) "...I think kitchen could probably have another heater because it gets quite cold there because it's quite big and in the winter it might be a bit chilli to be in there..."

While Marion’s account does not explicitly discuss avoiding the kitchen due to its uncomfortably low temperature she does project and unpleasantly cold environment for the winter months, which may potentially prompt him to avoid the space.

Socialization

Socializing is a key need for occupants moving to their new accommodations as exemplified by Andy below, who arrives to the accommodations and tries to know people around him.

(Andy@PPQ) “...in the whole accommodation, so I just went to different parties, made friends, get to know other people, made acquaintances, it was all good, basically, the first week, the first couple of weeks were just about parties “

(Wayne@PPQ) “...I think it's a nice, you know it brings people together, doesn't it...”

While socializing within the multi-tenant student apartment may also depend on the social relationships occupants already have with each other, the presence of kitchens that are perceived to be comfortable in accommodating social activities can be fairly assumed to facilitate group events. Michael below, although may not join all events his recounts tell of being accustomed to having potentially frequent social events in the accommodating kitchen:

Michael@PPQ “... I think flat parties, I was thinking I’m in the room by the kitchen...ohhh, dear.... but when they have flat parties in there, unless they are in the corridor I can’t hear them ”

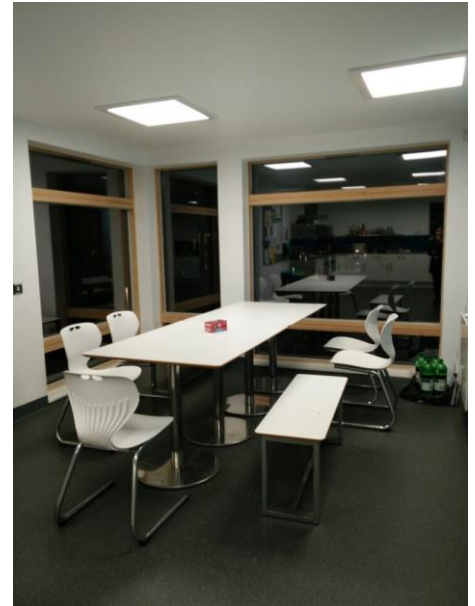


Figure 24. Group dining area and the kitchen.CC.

Andy’s recount also reveals that while he may not be using the kitchen of his apartment, he does join social events in other kitchens of occupants of the same building, who are in his social network.

(Andy@PPQ) “...Well first the kitchen was actually quite big, plus plus that I liked, although, I don’t really use the kitchen it’s a good thing to have a good, comfortable kitchen where you can sit and it’s more living room area, you have a table, workspace to do your cooking, that was good... Sometimes I go upstairs to my mate’s kitchen.”

Suzan highlights the building and the view from the kitchens and that she prepares dinner together with her cohabitants. In her case the kitchens also seem to be a place of knowledge exchange, besides social gatherings and cooking.

(Suzan@MH) "... it's a new building, the kitchen is amazing, ... , the view from my kitchen is amazing, ahm... and Yes (we have some chats in the kitchens) ... during preparing the dinner... " "I am enjoying cooking...when I cook and my flatmates come to the kitchen, oh my goodness what smells so good... so we talk about culture, we talk about food, you know, all of us cooks, sometimes we talk about fashion, we talk about travelling, you know, a couple of things we can discuss, which is good, it's kind of a cultural exchange, actually my roommate I told you, two of them are international students so in general you are talking about one, two, three, four, five, six...six cultures... You can learn about a lot of things... "

Similarly, Matt confirms the social nature the kitchens may have:

(Matt@PPQ) "...most of the time I tend to make my own meals but occasionally we do share meals... we all cook together and chat over the meal which is always good.."

Hence socialization may be conceptualized as a significant occupant need which if supported by the design of kitchens and communal areas of the accommodations may act as a stage for social gatherings, for partying, for cooking together that potentially has beneficial environmental outcomes via shared resource use these activities imply.

Attractiveness and Novelty

Some occupants while expressing their contentment with the kitchen of the accommodation, also highlight that the reason of selecting the accommodation in the first place was the fact that the building was new and that it has a nice - attractive kitchen.

(Harry@DDH) "...it was an intentional decision (to choose this specific accommodation), I really liked the fact that it was a brand-new building, yeah, we were the first one's in it and we have a really nice kitchen for example, ...nicely use, yeah, because I'm interested in architecture and design...I really wanted to go there...to be in a nice environment to do your studies..."

Harry also reports the use of the kitchen for cooking as a social activity.

(Harry@DDH) "...oh, yeah, definitely (we cook together), especially that one of my flatmates is really good in the kitchen preparing dinner and we just go into the kitchen and we cook..."

What this also means that the attractiveness and novelty of the kitchens may prompt occupants to use the space for group cooking practices potentially easing the environmental impact of the accommodation.

Conclusion

Student recounts of mundane activities reveal kitchen and living areas of the multi-occupancy apartments as focus points of meal preparation practices and of group events where student socialize. The design of the kitchens incorporating size, layout, windows and lighting systems, furniture and equipment, may act as facilitators of these activities when they are perceived by participants to be comfortable, to allow socialization and are found attractive via their novelty and aesthetics. Since the group activities, be it cooking or just spending time together, have a character of shared resource use these may also be considered as environmentally beneficial.

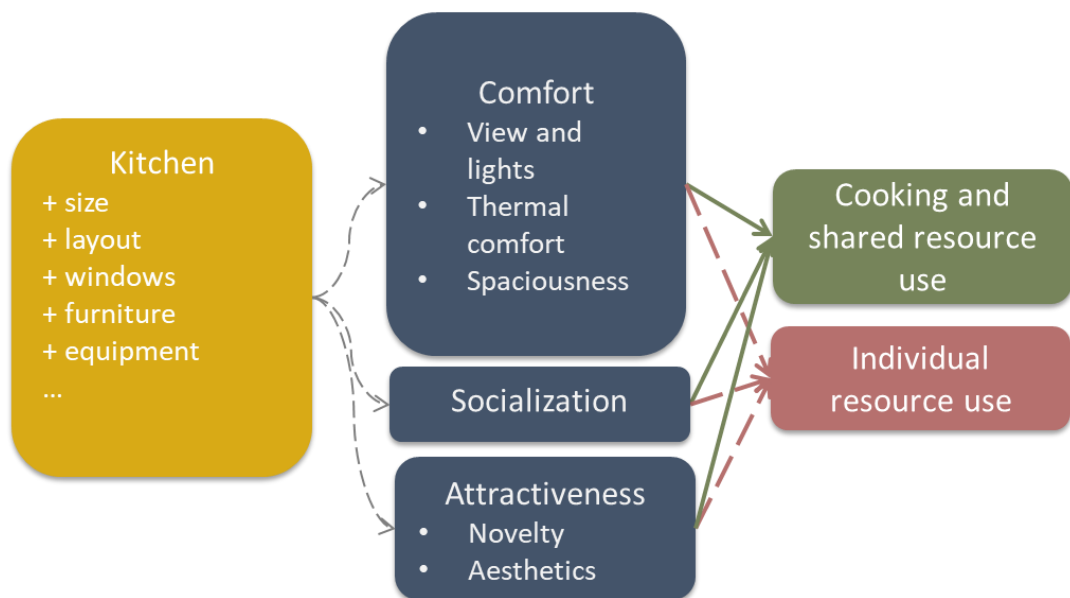


Figure 25. Cooking and shared resource use

Figure 25. is the graphical representation of how the kitchen design may relate of perceived occupant needs and the potentially resulting environmentally significant occupant behaviours. The environmentally more detrimental occupant action of using resources individually, and potentially increased waste generation, are linked to occupant needs of comfort, socialization and attractiveness with dashed red lines since the occupant recounts do not discuss whether the missing design support of these needs is a strong enough deterrent to moderate use of kitchen and living areas for cooking and group activities.

4.3.2.4. Waste management and recycling

Ease of use – recognizability and guidance

One of the many aspects of the recycling facilities that seem to support or hinder recycling practices are the *visual signs* informing and guiding occupants on how to adequately separate waste and as such making recycling easy.

When looking at the bins in the student flats, students, such as Jaden, report no obstacles in recycling because the signs on the bins are clear and enable separation of waste correctly. They also report people from their social network are picking up recycling and weaving that into their fabric of daily habits.

(Jaden@DDH) "... So you know, recycling, there is a big sign on our bins saying it's a recycle bin and we've got compost bins ... I think it's convenient for everyone, so a lot of people are choosing to do that way..."

Kim and Nancy also convey that recycling in their accommodation is easy and straightforward and report having started to recycle since they moved into their new accommodation at PPQ (see Figure 26.).



Figure 26. Waste bins guiding recycling.

At the same time, other participants like Harry, talk about the recycling facilities from the basement of their accommodation. He complains that the signage of the bins are uniform and therefore it does not help recognize their function, making recycling difficult. Later, he also reports his flat stopped recycling, since his cohabitants do not believe anyone could tell the difference what bins were meant to hold which type of waste in the basement.

(Harry @DDH) "I don't know, because they are all just same bins that have the exact same label, they don't stand out for me."



Although there are signs on the wall applied with the potential intention to guide occupants on where to discard what type of waste, on Figure 27., it is well

Figure 27. Scattered, uniform receptacles making recycling unclear.

visible that the bins are scattered and hence it is not clear which label matches which bin. When Harry mentioned that the bins "have the exact same label", he probably meant to highlight this

particular shortcoming of the waste management facilities. Given the labels are not guiding in this case since the bins are scattered, the colour of the bins could be another guidance on how to adequately separate waste. However, as it is well visible, the bins all have the same colour, as also revealed by Harry when saying “they are all just same bins”. Therefore, recycling is perceived as cumbersome and difficult due to the lack of recognizability of the destination of the waste and lack of visual guidance.

The above examples illustrate well the importance for the bins to be perceived as easy to use via visuals guiding sustainable behaviours, in order for sustainable waste separation to happen.

Furthermore, these stories are also telling of the importance of ensuring ease of use by providing clear visuals along a pro-environmental process that happens in several stages. Perceiving recycling easy and having the recycle bins stand out in the flat is not enough if in later stages of the waste management process it is not clear where residents should deposit the separated waste and hence the recycling is perceived to be less easy. Thus, each stage should support occupant needs of ease of use by providing clear and easy to follow guidance on how to separate waste correctly. Figure 28. depicts the waste management of a facility where several visual signals and guidance is likely to help occupants recycle more easily.



Figure 28. Colour coded and grouped receptacles supporting recycling.

Ease of use – interaction with the bins

Another aspect which seems to shape waste separation and recycling practices is the occupant perception of how easy it is to interact and use the bins. When occupants report depositing the waste physically cumbersome, it seems to act as a barrier for correct recycling and waste management. In this case, occupants discuss waste disposal shafts outside the building. Although the shafts are well differentiated by separate colours and separate openings potentially aiding separation and recycling, occupants



Figure 29. Waste shafts PPQ

report not to recycle due to difficulties in interacting with the facilities. For instance, Martin’s recount reveals that the waste bags do not fit into the shafts. Figure 29. shows the shafts as PPQ.

(Michael@PPQ) "...the recycling scheme you've got outside, the bins...very interesting concept of having shafts to a car park down below, ahm...it does work and it doesn't work, because the shafts get full and they overflow and then you obviously have to like have overflowed bins in and it's just a bit of a chaos..."

Andy's recount reveals that the issue with the waste shafts is that the lid does not open entirely, making discarding the waste bags difficult.

(Andy@PPQ) "...Not really...if I'm honest because at the beginning I tried to like put the recycling items in the recycle bin but when you go downstairs to throw them first of all they have like four bins for the bin bags...those four bins they are not really, I mean they don't really work, because they don't even open totally... so they just put the bin bags outside and that area where the bins usually are and you just throw the bin bags there...it's not like recycling it's all trash..."

The above examples depict the importance of perceived ease of use of interaction with the bins. Even though discarding waste is perceived easy in terms of where to put which type of waste, the interaction itself is still perceived difficult, potentially leading occupants not to discard waste in the right place and hence not to recycle. Furthermore, the lack of perceived ease of use of interacting with the bins, besides interfering with correct waste separation and recycling practices seems to also promote littering since occupants report abandoning the waste bags next to the shafts.

When prompted on potential solutions to the issue above occupants reveal preference to have the waste shafts in the kitchen that transports the rubbish down, so they do not need to come down with the bags and discard them outside the building.

(Andy@PPQ)"...one thing we can actually do is the recycling bins to fit them properly to have recycling bins directly from the kitchen and go all the way downstairs... so you don't have to travel to get the bin bags outdoors so you can throw them directly ... if you have them in front of you have to do actually nothing, you can actually recycle...why you have to go through all the trouble and not to throw your bin bag in any bin you find there..."

In conclusion, perceived ease of interacting with waste management facilities seems to be conducive of correct waste separation and recycling. Where facilities are perceived to be cumbersome to interact with, occupants may abandon recycling despite best efforts to provide visual signals that would otherwise aid and guide them to recycle correctly.

Comfort– proximity of the bins

Recycling may also be helped or hampered by the comfort of performing the action. In the present analysis comfort was associated with the perceived proximity of the receptacles. To

exemplify, some residents report not to recycle when in their bedroom since they find the recycle bins, which are in the kitchen, to be very distant.

(John@DDH) "... yeah, I mean if I'm working at my desk and there are things like paper rubbish that's normally what the problem is, ahm, it's sounds terrible to not be bothered because the kitchen is so close but at the same time if you're walking away I don't really want to make a pile of paper waste on my bed and carry out later, so the easiest thing is to just dump it in the bin by your feet but yes, it's general waste it's not recyclable...if there was a bin which had a section for recycling staff, yeah I would use that definitely than you know carry that to main bin once a week but there

isn't so it's a small amount of staff to get through but it does happen ..."



Figure 30. Paper waste while working

(Matt@PPQ) "In my room I probably don't recycle, but in the kitchen, we recycle separate things, while in my room I can't recycle because there is one bin."

In other cases, however, students report going for some distance to dispose of waste correctly.

(Jack@DDH) "...I just jump in the lift outside of my flat, go to the ground floor, come out and the bins are there...very convenient ...and it's very useful I have to say..."

This raises the question what is comfortably "near" in recycling. It may well be that the differentiating factor is not the physical distance but other situational factors. John above is in his room, working at his desk. Recycling a sheet of paper by using a recycle bin in another area of the apartment means interrupting work, breaking focus, performing the recycling, then returning and refocusing on work. This may just be too much of an effort. Instead John uses the general waste bin in his room which allows him more comfort and uninterrupted work. It may also well be that, if occupants are in the comfort and privacy of their rooms, even if they are not working, they may find it uncomfortable to leave their private space to recycle. On the other hand, Jack recounts of "jumping" into the elevator and going downstairs to dispose of waste. This might be a different from John's case since Jack does not seem to be interrupting a focus-demanding activity for recycling. Furthermore, Jack may already be outside a very private context, so he is not giving up privacy.

Thus, the perceived comfort of the proximity or location of the bins may be significant in how sustainably occupants manage the waste. This also means that in sustainable accommodations having recycle bins in student rooms may aid occupants in their recycling behaviour and improve on overall waste management.

Hygiene – cleanliness of the bins

The studied cases show that wherever it is unhygienic to dispose of the waste correctly, students may stop recycling and not recycling becomes the common way of managing waste in the multi-resident flats. The case of a participant who is swayed to take this path of action stands out here. The occupant reports strong initial intentions to recycle already having had the habit of recycling from home. They notice the bins get dirty easily and they make repeated efforts to clean those, but finally give up on recycling due to hygiene concerns. Hence, the perceived lack of hygiene of a sustainability-serving device completely deters participants



Figure 31. Unhygienic bins deterring recycling.

from performing a pro-environmental behaviour despite earlier positive habits and strong pro-environmental attitudes.

(Harry@DDH)“From the start we moved in people just became put off putting things in that bin very quickly...because it got dirty, it was very-very small, very filthy to install a bin lining to it ... I cleaned this entire thing in my shower-cubicle a few times which is utterly disgusting trying to remove things...so at that point we just didn’t bother any more...”

Figure 31. shows the problematic bins, with the small, black, lid-covered openings for refuse waste and large openings for recyclables.

In conclusion, the present study argues that perceived hygiene of using the recycle and waste bins may be a significant contributor to how sustainably occupants manage their waste.

Conclusion

Overall recycling and waste management in student accommodations is reflected by occupant recounts to be a complex and multi-stage process potentially sensitive to several aspects of how occupants perceive key qualities of the waste management facilities. When facilities are perceived easy to use due to recognizability aided by good visual guidance, and ease of interaction, recycling behaviours seem to be more prevalent. Additionally, perceived comfort of the proximity and location of the bins may also sway sustainability of waste management practices. Finally, how far occupants perceive the facilities to support their need for hygiene may also be a significant factor in sustainability of waste disposal behaviours. Figure 32. summarizes the relationships inferred.

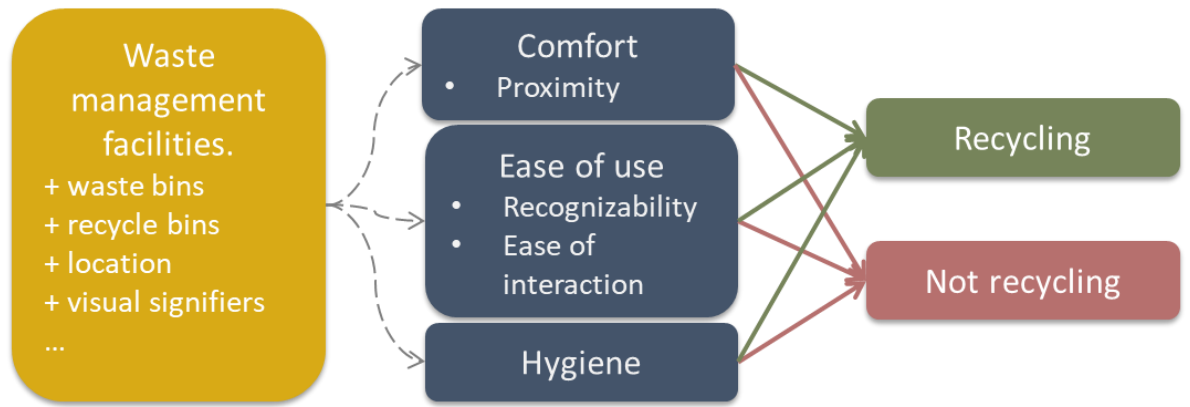


Figure 32. Recycling behaviour

4.3.2.5. Vertical transport

Stair use and elevator use are mundane and frequent within the accommodations and may impact the energy consumption of the building. The more often occupants use the stairs, the least often they use the elevators and hence the least electricity the building may use.

Comfort

The occupant recounts reveal that when the accommodations are equipped with both stairs and elevators, residents tend to prefer taking the elevators.

(Jack@DDH) "...I live at the seventh floor but there are eight floors up so mean I never really take the stairs ... "

The same occupant does not only take the elevator for ascending in the building but also for descending.

(Jack@DDH) "...I just jump in the lift outside of my flat, go to the ground floor come out and the bins are there... "

While taking the elevators, whether ascending or descending, could be acceptable in case of Jack as he lives on the seventh floor, he also mentions that using the elevator instead of the stairs is the norm in the accommodation, regardless of floor level.

(Jack@DDH) "...but by and large everyone takes the lift... "

This assumption is supported by the recounts of occupants of other accommodations, hence it may be a general, place-independent pattern:

(Marion@CC) "...I'm on the second floor, I'm not going to lie, I always take the elevator ..."

Marion's account further supports the assumption that occupants of sustainable student accommodations, independent of the floor level where they reside, mainly rely on the elevators. The main reason behind avoiding the stairs is reported to be the physical comfort elevators afford by saving effort required for walking the stairs, thus the comfort of effortlessly getting from one floor to another. With other words, taking the elevator is perceived to be physically easier and less strenuous than walking the stairs, which is not a surprising result.

(Marion@CC) "...it's just convenient you know, maybe if I was on the first floor, I would take the stairs but the second floor.... I just feel like it's two floors let me just take the elevator climbing up is always elevator, always..."

Marion goes on revealing that many people take the elevator even if they reside on lower floors, which echoes Jack's recounts. The main reasons behind that is perceived to be the comfort it affords both physically and in terms of waiting time.

(Marion@CC) "I think stairs are popular from the first floor and I've seen people from the first floor take the elevator as well as a few times and I mean I don't want to complain but people do take the elevator even from the first; third floor fourth floor you expect them to take the elevator unless someone is in a rush yeah I think it given the choice majority of the people will take the elevator because it's little effort press the button you go down if you're in a rush maybe let me just take the elevator it's quicker or maybe just take the stairs..."

Nevertheless, seconds later the same participant softens his accounts that *"I always take the elevator"* and he reveals that although usually he takes the elevator, sometimes he also takes the stairs:

(Marion@CC) "...usually take the elevator ... I've rarely taken the stairs; descending is maybe half half..."

She reveals that although taking the elevator is more convenient and comfortable, occasionally he does take the stairs especially when he descends in the building. This latter is an interesting finding if we compare it with Jacks' account presented above. Although both participants report excessive elevator use, the one who lives on the second-floor reports to take the stairs for descending compared with the other participant from the seventh floor who only uses the elevator, irrespective of whether he travels up or down. This could mean that there might be a relationship between the floor level student reside and stair/elevator use. The higher occupants reside in the building the more likely it may be they will always choose the elevator instead of the stairs even for descending. Conversely, the lower they reside, the more likely they will also choose the stairs for descending.

Marion continues revealing that in fact she does sometimes take the stairs:

(Marion@CC) "I think out of 10 times I will take the elevator seven times..."

and that first floor residents may be using stairs more commonly:

(Marion@CC) "I think stairs are popular from the first floor and I've seen people from the first floor take the elevator as well as a few times"

Overall, the recounts above imply that staircase use may be significantly reduced by perceiving their use as more effortful and less comfortable than the use of their electricity intensive alternative, the lifts. The lower floor levels may facilitate use of stairs to some extent since

occupants may perceive the effort implied to use them as acceptable. However even lower level residents seem to be heavy elevator users and take the stairs mainly to descend – which is potentially perceived as significantly more comfortable than climbing the stairs.

Waiting times perceived uncomfortably long also seem to tip the balance in the favour of stair use.

(Marion@CC) "...usually why I don't take the elevator is like when I come press the elevator button and if it does not come immediately then I take the stairs..." and "...unless someone is in a rush yeah I think it given the choice majority of the people will take the elevator..."

Which means that staircase use may become the more attractive option when they are perceived as the faster mode of vertical transport.

Finally, besides the comfort of lower effort and faster transport, convenience of location may be an additional component of comfort that may be significant in using stairs. Jaden's below explains that having stairs in a more approachable location may prompt occupants to use those more frequently.

(Jaden@DDH) "so if there would be stairs that where I could just walk straight through ... going straight up...to the flat that would be quite easy... (however) it's not necessarily convenient to take the stairs if you have to (go around) "

In Jaden's accommodations the stairs taking up to the student rooms can be accessed via a route that may be found cumbersome for occupants to take. Conversely, the elevators are easier to access making those the first choice of occupants. It can be argued that stairs located more conveniently than elevators may prompt occupants to choose the stairs more often, at least for reaching the lower floors.

Health

Marion's reasons for taking the stairs instead of the elevators also reveal the scenario when occupants return from sport related activities and want to avoid cognitive dissonance taking the elevator would create.

(Marion@CC) "... just that I only take the staircase when I've gone or come back from the gym, because I don't like okay I'm just coming from the gym I might just take the stairs ..."

Hence, stair use may be perceived as a healthy activity while elevator use as a less healthy mode of vertical transport, potentially explaining why Marion chooses stairs over elevators when she returns from the gym. Suzan below also associates stair use with health, and although a stair user

out of necessity not out of choice, her association enforces that stair use is perceived as a health conducive activity.

(Suzan@MH) "...thanks there is no lift because I would get fat ..." and "... this is nothing (referring to climbing stairs) ... you just convince yourself that it's good to do some exercise ..."

Therefore, it may be assumed that perceiving stairs as health supportive vertical transport devices may facilitate their use as an alternative to elevators, concomitantly moderating the environmental toll of elevators.

Attractiveness

Finally, some participants argue that making stairs more attractive may potentially sway, at least lower level, residents to use them more frequently.

(Zia@CC) "...2nd and upper floor people don't use the stairs, so if they could make that more interesting would be cool..."

While this is a completely hypothetical argument, it may well be valid that having stairs that are perceived attractive may prompt occupants to explore and use the stairs.

Conclusion

Occupants of sustainable accommodations seem to rely heavily on elevators instead of stairs, which is considered to generate higher energy use and therefore is more environmentally detrimental. While higher level residents seem to be permanent users of elevators lower level

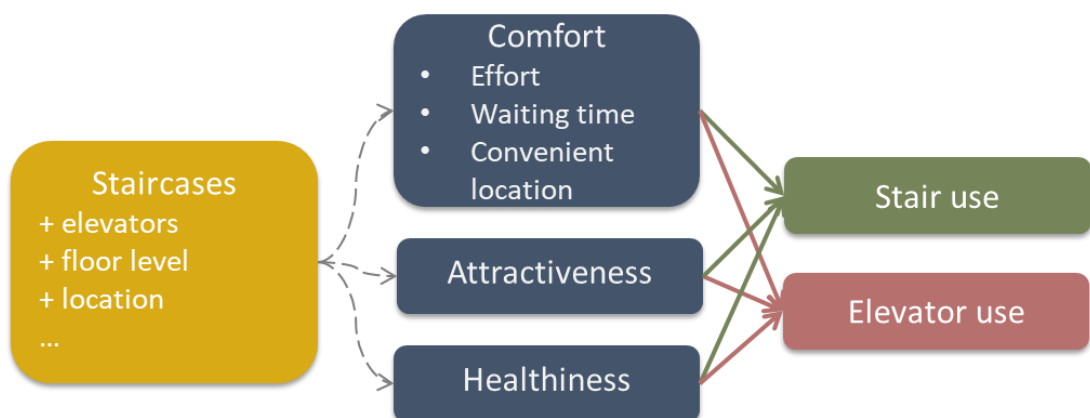


Figure 33. Stair use in sustainable accommodations.

residents – up to second floor - may occasionally use the stairs. Stair use seems to become a viable alternative to elevator use when the comfort associated to using stairs competes with that of elevator use. Based on occupant recounts, comfort seems to mean the perceived effort needed to take the stairs, the conveniently short time to complete the vertical transport and the

convenience of the location of the stairs. When staircases are perceived to provide comfortable use along the meaning mentioned above, occupants may be more likely to use the stairs. Additionally, some results indicate that attractiveness of staircases may also attract more frequent stair use. Finally, stair use may be associated to health beliefs of occupants. Hence staircases that convey health related images or messages may be perceived by occupants as a healthier option and possibly prompt more prevalent use. Figure 33. depicts how the stairs with the related and sometimes competing design features, together are being perceived by occupants to support their needs for comfort, health and attractiveness, potentially tilting behaviours between stair use or elevator use.

4.4. Conclusion – emergence of the FNB map

The present study set out to fill the literature gap and understand how sustainable accommodations may afford sustainable occupant behaviours through the lenses of occupant perceptions. By relying on data gathered and analysed with Grounded Theory, it arrives to a set of inferences that may constitute a consistent answer to the question it set out to respond to, and points towards newly constructed theoretical understanding.

More specifically, the occupant recounts of living in sustainable accommodations reveal a set of behaviour patterns, some of which may be supportive of sustainability while others may be detrimental. The sustainability of the underlying occupant behaviours seems to be swayed by various occupant perceptions linked to the sustainable building. These perceptions are concerned with occupant needs, more precisely with how occupant needs are perceived to be supported or hindered by the sustainable building (high-level affordances), and its design features (detailed affordances). Hence, the need supportive quality of the sustainable accommodation and its relationship with the sustainability of occupant behaviour becomes apparent.

When the sustainable accommodation is perceived by future and present occupants to match their multifaceted expectations and needs (high-level affordances) such as privacy, safety and security, novelty or modern appearance and are believed to be sustainable due to their novelty and modern appearance, occupants may choose to live in the sustainable accommodations and may report becoming more sustainable. Conversely, when the buildings are perceived not to support needs such as privacy, anecdotal evidence suggests that residents may take a less sustainable decision and leave their accommodations, and move to other, potentially less sustainable residences. Therefore, ensuring that the sustainable accommodation is perceived to afford, and support occupant needs identified in this study, might be vital for encouraging occupants to make the sustainable choice of moving into and living in sustainable accommodations and to ensuring good occupancy rates in sustainable accommodations.

On a more granular level, much closer to building features, a similar pattern emerged from the analytic process. When occupants perceive the building features support needs such as comfort, control, privacy ease of use or hygiene, their environmentally significant behaviours such as light use, heating and ventilation, or waste management seem to be more sustainable. Conversely, when the same needs are less well supported by the design, occupant recounts reveal less sustainable light use, heating and ventilation, and waste management practices to name but a few. The sub-sections of “4.3.2 Detailed affordances and sustainable behaviours” leading up to this conclusion, discuss and visualize individually the design features (F) found potentially

significant in swaying sustainable actions, the occupant needs (N) those features may have to support in order to promote sustainable use, and the resulting environmentally significant behaviours (B) of occupants. Overlaying the visual representations of features, occupant needs and relevant behaviours the below (FNB) map results (Figure 35), strongly suggesting that the perceived support of occupant needs might also be crucial on a detailed level to enable and promote sustainable occupant behaviours in the sustainable accommodations.

At the first glance, the FNB map (Figure 35) also seems to indicate via the level of interconnectedness of the labels, the occupant needs that are most important to be supported by design in order to enable sustainable use. As such, occupant comfort is connected to most design features and to the most occupant behaviours, signalling it is pivotal to supporting sustainable behaviours by design. This may initially entice designers to focus first and foremost on the

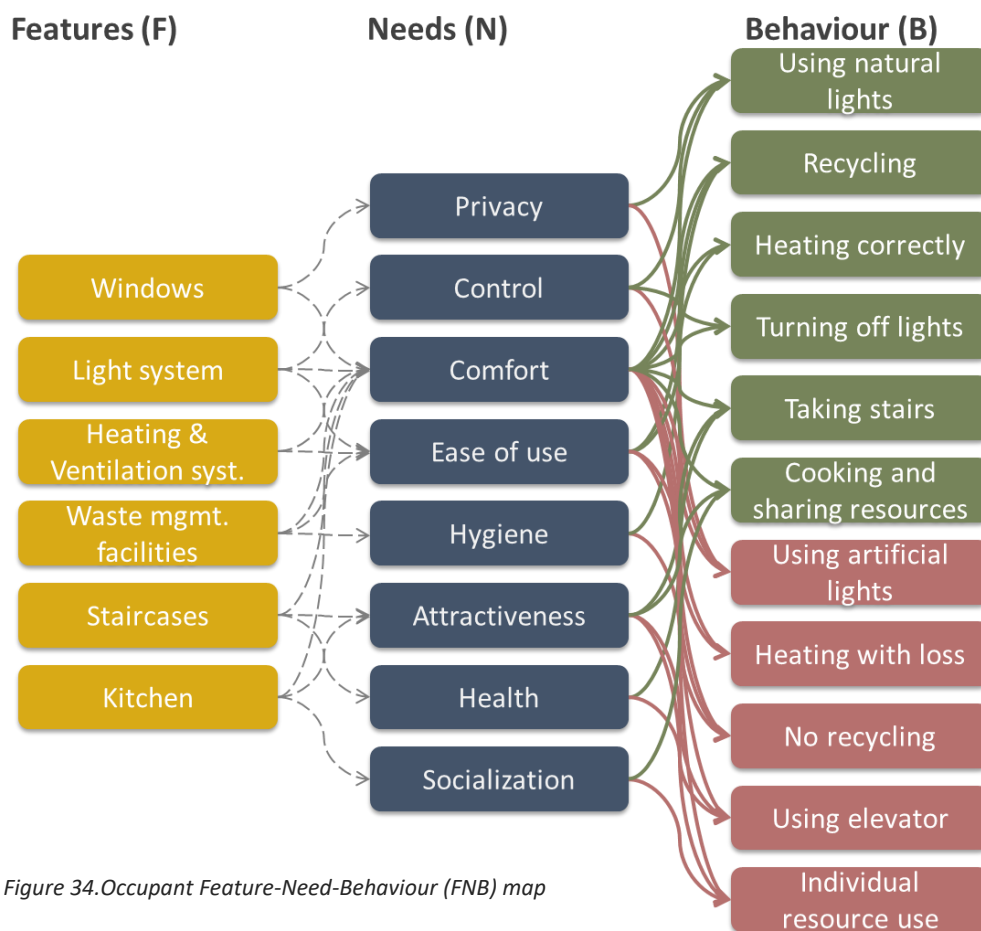


Figure 34. Occupant Feature-Need-Behaviour (FNB) map

support of the most well-connected needs by design. However, the case of privacy and light use advises strongly against overlooking less well-connected needs from the FNB map. As previously shown in the section on privacy and light use in rooms, although occupants favour natural light and enjoy the comfort of good daylight which may prompt reduced artificial light use, when privacy is perceived missing occupants sacrifice natural light to restore privacy, and use artificial

light during the day. This means that all expected sustainability advantages of designing a comfortably bright room may be annulled by ill-supported privacy in bedrooms, potentially explaining part of the paradox of unsustainable use of technically sustainable buildings. Therefore, this study advocates for simultaneous design support for all occupant needs on the FNB table when designing for sustainable occupant behaviour. While this might be considered a significant additional challenge for architecture, the contention of the researcher based on their earlier design experience is that since architectural design is already equipped with methods to cater for a plethora of hard and soft requirements and regulations, it may also accommodate a structured support for occupant needs within reasonable effort.

In conclusion, the overarching theoretical understanding developed from the data is that the sustainability of occupant behaviours may be shaped by how far the building, in this case the sustainable accommodation, and its architectural elements and design features are perceived by occupants to be supportive of occupant needs. This was found relevant for both: behaviours governed by high-level affordances such as selecting or leaving sustainable accommodations; and behaviours involving specific building elements and features – governed by perceived support of occupant needs or detailed affordances; constituting two pillars for the developed theoretical understanding. However, the latter group, the interactions with more granular building features, are the ones of central concern for this thesis, given its clearer and more direct connection to the sustainability of the sustainable accommodation and is therefore further investigated in upcoming chapters.

5. Occupant Survey Study

5.1. Introduction

The present study aims to verify quantitatively the theoretical understanding developed qualitatively from the Occupant Interview Study, in order to complement and increase the validity of the findings. The analysis of occupant interviews inferred a map of design features that might be related to specific environmentally significant behaviours through the fulfilment of residents' needs such as *comfort, control, privacy, ease of use and hygiene*. The quantitative study seeks statistical support for the most salient relationships (Figure 36.) between the fulfilment of residents' needs and environmental considerate behaviours, further contributing to answering the first research question of the thesis:

How do occupants of sustainable student accommodations perceive the building affords environmentally sustainable behaviours and building interactions?

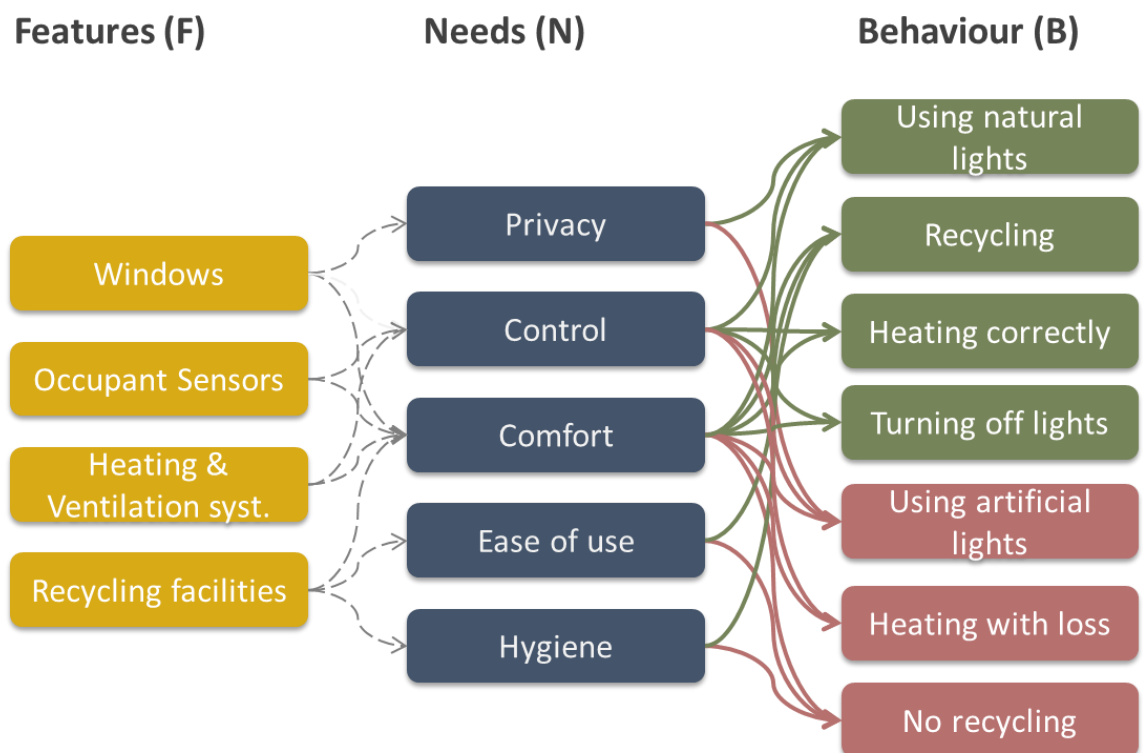


Figure 36. Inferences from occupant interviews

Those theorised need support - behaviour relationships which are found to be statistically significant by the present study, will constitute the core focus of the thesis.

The chapter will continue with the Methodology section detailing the methodological considerations, the design of the questionnaire, sampling and data collection, and data analysis.

This will be followed by the Result section providing a comprehensive presentation of the results of the statistical tests. Finally, the Conclusion section will end this chapter.

5.2. Methodology

5.2.1. Methodological considerations

In order to statistically explore the relationship between residents' needs and their environmentally significant behaviours in the investigated accommodations, the research considered a range of data gathering methods that could fit the aim.

Online occupant surveying was identified as the ideal data gathering method since it allows capturing occupant perceptions of their environment and reporting behaviours performed in highly private, home-like environments hardly accessible to other data gathering methods such as observations. Furthermore, surveys allow prompting for reasoning on certain actions, which observations or energy use measurements cannot provide. Additionally, online surveys became the method of choice also due to the resource limitations the PhD research faced. Finally, online surveys can be made accessible to a large number of occupants increasing the validity of the findings.

Collection of secondary data, such as energy use measurement or water use measurements, was also considered. However, the sites only had aggregated data by building block or by floor level and not at the granularity required by the study (i.e. at room level). Furthermore, the operators of investigated sites handled all energy use and water use data with confidentiality and resisted invitations to share any type of consumption data.

5.2.2. Designing the questionnaire

The final questionnaire, also included in the Appendix 10.5 of this thesis, consisted of 55 questions grouped in five main sections. The first four sections focused on natural and artificial light use in student rooms; natural and artificial light use in the living and kitchen areas; heating and ventilation practices in student rooms; and waste management practices in student rooms, kitchens and communal areas of the studied accommodations. The final section prompted for demographic data on age, gender, geographic origin, occupancy details such as residency duration, and floor level and room orientation.

Each of the first four sections prompted for students' perceptions of the indoor environmental qualities, the related environmental and energy relevant behaviours and reasoning of those behaviours. The rationale behind selecting the included behaviours is their frequent recurrence in

the interviews of the Occupant Interview Study. This naturally meant that not all inferences of the interview study could be verified. However, the decision had to be made in order to control the size of the questionnaire.

The questions of the questionnaire were formulated by systematically reviewing student recounts from the interviews and phrasing questions and answers in the manner of those recounts. Each section of the questionnaire that focused on perceptions and behaviours contained:

- Questions capturing the perceptions associated to the physical environment such as brightness of a room, or perceived temperature. These questions generated ordinal data from five points, Likert-scale questions. E.g. Q3_1 to Q3_5 of the Occupant Survey from the Appendix.
- Questions prompting for specific behaviours such as duration of using artificial lights or frequency of recycling. These questions generated ratio/interval data where possible. E.g. See Q7 or Q11 of the Occupant Survey from the Appendix.
- Questions for capturing reasoning for performing behaviours of interest. These questions generated nominal data. E.g. See Q6 or Q9 of the Occupant Survey from the Appendix.

The questions capturing occupant perceptions of indoor environmental qualities (IEQ) of their residence were developed using two considerations. The primary base was the way occupants explained in the interviews how they perceived their residence in terms of brightness, temperature or air quality. Second, a review of the most widely used standardised surveys concerned, among others, with perceptions of IEQ, was undertaken and their common use of questions with 4-7 point scale answers ([Galatioto et al., 2013](#)) was adopted to facilitate statistical analysis.

Perception related questions not directly linked to IEQ, such as the questions capturing visual privacy or the cleanliness of waste management facilities, were constructed from occupant interviews and generated 5-point, ordinal data, that would allow correlational explorations. These questions asked respondents to mark how far they agreed or disagreed with a predefined statement, with the middle choice being neutral. Or to mark how they assessed a specific aspect of a design feature on a pre-defined scale with a neutral middle choice. The aspects prompted for, such as cleanliness of a bin or ease of use of a design feature, had been identified in the Occupant Interview Study.

The questions assessing sustainability of behaviours were phrased in a manner that would quantify the use of a resource, such as light or heating, and would allow generation of ratio data.

In these cases, the questionnaire captured time duration of resource use. However, some environmentally significant behaviours were not as straightforward to capture and make comparable. For instance, sustainability of waste management could not be measured in time. Instead, questions were designed to capture frequency and correctness of waste management, which combined, serve as an indicator for sustainability of waste management actions.

Finally, the questions capturing reasonings on behaviours were constructed from the interview responses. These appear in the survey as selectable responses to a question, allowing multiple choices, based on the researcher's assumption that the same action may be performed due to multiple reasons. Since reasons for actions were considered un-comparable concepts, the questions intended to generate nominal data.

In line with best practices applicable for survey studies (van Teijlingen & Hundley, 2001), a pilot study was performed to test the clarity and relevance of the questions, and the duration of taking the survey. Participants in the pilot study were sampled from the four sites of interest. A professor of Environmental Psychology has also been asked to provide feedback on the questionnaire. The provided expert and respondent feedback were incorporated in the final version across six iterations of improvements, increasing the internal validity of the questionnaire. Finally, the online questionnaire was built and made available through the Bristol Online Survey tool (www.onlinesurveys.ac.uk).

5.2.3. Sampling and data collection

Pilot study

Residents of the studied accommodations were invited to provide feedback on the preliminary questionnaire. They were contacted through social media groups of the accommodations or through email already provided in the interview study with their consent for being contacted for further studies. Interested participants were asked to complete the preliminary questionnaire and to provide feedback on the wording and clarity of the questions and on the necessary time to complete the survey. The respondents signalled that, for instance, self-regulating ventilation devices are not commonly known to students and the term "trickle vent" may be more commonly used. They also suggested, that including images of trickle vents would ease identifying those. Consequently, two example links showing pictures of trickle vents from the studied accommodations were added to the survey at Q25 (Appendix 10.5). Similarly, the original wording to describe light sources in the room was changed from the use of initial '*lamp*' to '*light*' since the pilot participants felt the use of '*lamp*' archaic. Additionally, questions aiming to grasp *duration* of

light-use were changed from an initially open-ended response form to a set of predefined options. Finally, when pilot participants provided comments such as “Possibly simplify the choices; I got confused in terms of middle-high and middle-low for instance, it’s difficult to figure out what they would be.”, the response choices were rephrased.

The survey was updated with each feedback and the updated surveys were sent out to those participants who had not responded by the time of the refinement. The final form of the questionnaire received respondent comments such as: “The questions that follow are very precise and to the point and very easy to understand and thus answer.” and “Timewise it is completely fine, doesn’t take too long.”, signalling that the survey achieved an appropriate level of clarity and relevance, and that the completion time is acceptable for respondents.

Survey

Due to the moderate participation web-surveys can be expected to yield (Manfreda et al., 2008) commonly used methods to increase participation rates were applied (Nulty, 2008; Pedersen & Nielsen, 2016). First, the email invitations included a cover letter explaining the goal and the nature of the survey, highlighted the organizing institution and the funding of the research, and stressed the importance of each participant while reassuring participant anonymity. Second, a lottery, offering the possibility to win one of the three prizes of £100, £60 respectively £40 was organized. The prize draw was highlighted both in the email invitations and on the social media posts. Thirdly, to make accessing the survey easy, a direct link to the online survey was included in the email invitation. The survey was designed to remain accessible for several weeks to allow time for residents to complete it. Additionally, the number of invites and reminders was limited to avoid annoying and deterring participants. Finally, the online questionnaire consisted of relevant, easy to follow, and clear questions, with few open ended questions, which became visible in small groups, while a progress bar showed where the respondents were in completing the survey, in line with literature on best practices of designing online surveys (Bryman, 2012).

The accommodation providers of each site were asked to reach out and invite all residents of the designated buildings to complete the online survey. This was intended to ensure all occupants had an equal chance to participate. The Accommodation providers were asked to send an initial email invitation and one follow-up email reminder two weeks after the first email. However, on the largest site, email invitations could not be sent by the university neither by the accommodation provider. Therefore, the moderators of the social media group wall of the accommodation were asked to allow the researcher to post invitations.

The sole participation criterion was to be current resident of the studied sustainable accommodations. The questionnaire was accessible online from mid-March to mid-April 2017. The responses were verified with respect to place of residence and contact details of participants. Duplicate entries originating from participants giving identical name or email address and entries from residents living outside the studies accommodations were excluded from the analysis. In total N=222 responses were considered. "Table 6. Sample details." shows the final number of participants included in the study by studied site, gender, and geographic origin.

Considering the maximum 2429 capacity of the buildings, the participation rate can be estimated to be 9.13% at worst. The exact participation rate is not known for two reasons. First, an unknown number of rooms stood unoccupied at the time of the survey. Second, at the largest site with a capacity of 1367 beds, the occupants could only be recruited via the social media group wall of the accommodation. However, it is unknown how many residents were members of the social media group and how many members were readers of the group posts. Hence, the estimated 9.13% represents the worst-case scenario with the real participation rate likely being higher. Nevertheless, 9.13% is at lower end of what is commonly observed with online surveys (Manfreda et al., 2008; Nulty, 2008). Possible explanations could be the over-surveying of students and that the survey was not performed and "pushed" by the home institutions. For instance, the researcher observed in the social media group of the largest site, that it was common and frequent for commercial advertisers to gain membership and run multiple non-academic surveys and polls, potentially leading to members' fatigue, which in turn might have reduced the willingness to participate in the present survey, partially explaining the modest response rate.

Even if the response rate was known, it may not be adequate in assessing the representativeness of the collected data given random sampling cannot be claimed. Furthermore, while it is theorized the occupant sample is homogenous, no strong claim can be made as to whether there are systematic differences between respondents and non-respondents, which is a key indicator in identifying potential non-response bias (Krejci, 2010 in Fulton, 2018) that may plague external validity of a study (Rogelberg and Stanton 2007 in Fulton, 2018).

The final questionnaire can be found in the Appendix 10.5 of the thesis. Questions of the survey are referred to as "Qx" hereafter, where "x" refers to the question number.

Table 6. Sample details.

Site	Accommodations size	No of participants	Estimated, worst-case response rate	Gender distribution	Origin
Mountain Halls	5 buildings 476 beds	69	14.49%	46 females 23 males	55 UK 14 Overseas
Daniel Defoe Hall	3 buildings 355 beds	46	12.95%	32 females 13 males; 1 undisclosed	29 UK 17 Overseas
Peel Park Quarter	8 building 1367 beds	81	5.92%	60 females 21 males	71 UK 10 Overseas
Crome Court	1 building 231 beds	26	11.25%	12 females 14 males	1 UK 25 Overseas
Total	17 building 2429 beds	222	9.13%	150 females 71 males 1 undisclosed	156 UK 66 Overseas

5.2.4. Data analysis

The primary aim of the analysis was to find statistical support for the relationships between residents' needs on one hand and environmentally significant behaviours on the other, as suggested by the earlier Occupant Interview Study. A secondary focus was to reveal the frequency of respondents' reasoning behind their self-reported behaviours. Therefore, descriptive and inferential statistics were employed for analysing the data with IBM SPSS v23.0. The cross-sectional data underwent data reduction where necessary and was analysed using descriptive statistics, means comparisons, one-way analysis of variance, correlation analysis and exploratory multiple regression analysis.

On the figures of this chapter design features are coloured yellow, occupant needs are blue while behaviours are green when they are sustainable behaviours, and red when unsustainable. Where correlations are presented, connecting grey lines signify positive correlations while connecting red lines signify negative correlations.

5.3. Results

The survey data analysis performed with descriptive and inferential statistics provides quantitative support for many of the most prevalent relationships between design fulfilment of resident needs and environmentally relevant behaviours that had been inferred by the Occupant Interview Study. The analysis follows the structure of the questionnaire reporting on the following environmentally significant behaviours:

1. *Natural and artificial light use in student rooms;*
2. *Natural and artificial light use in the living areas/kitchens;*
3. *Heating and ventilating practices in student rooms;*
4. *Waste management practices in rooms, kitchens and communal spaces of student residences.*

Each behaviour section is further divided in sub-sections focusing on specific occupant needs that were found to be related to the respective behaviour.

5.3.1. Light use behaviour in student rooms

The student interviews inferred that artificial light use and natural light use behaviours in the rooms are related to how far Privacy and Comfort of residents is supported by the design of the rooms (Figure 37).

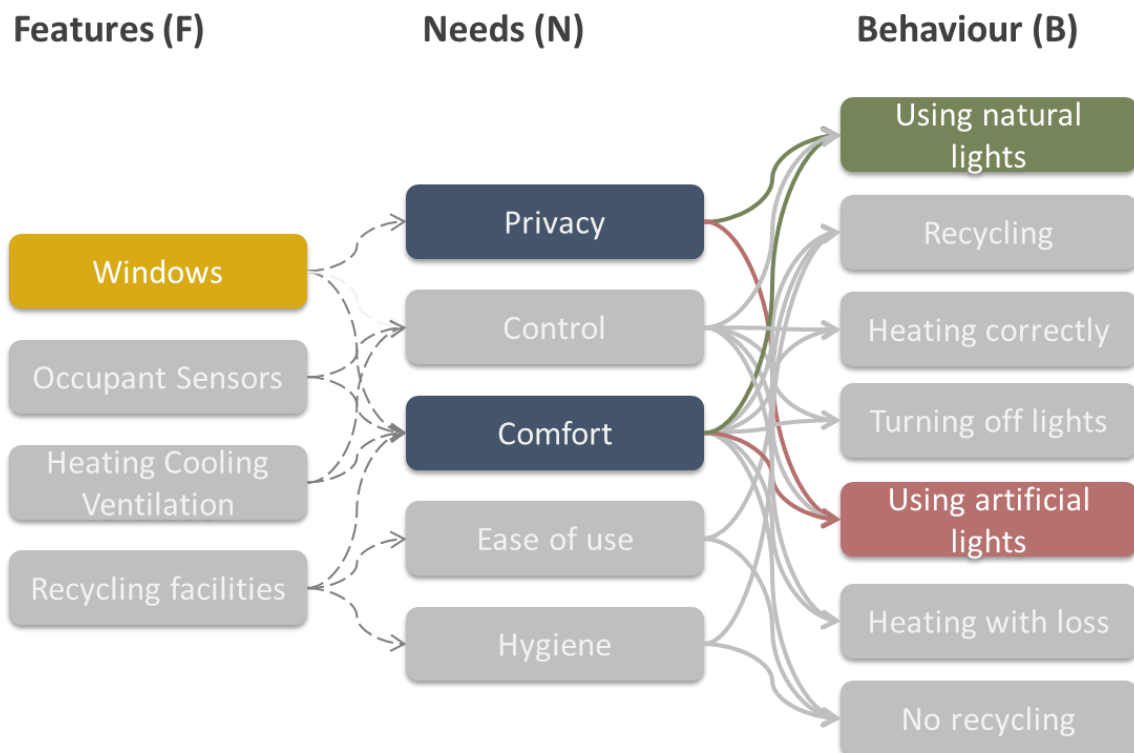


Figure 37. Room light use related Feature-Need-Behaviour map as inferred from the occupant interviews.

The concept of Privacy focused on Visual Privacy (Q3_4) in the rooms and was measured by how far students felt they can be seen through the window. The considered dimensions of Comfort were discomfort glare (Q3_1), perceived overheating due to solar gains (Q3_2), natural light levels for work(Q3_3) and brightness of the room(Q3_5). Since the occupant interviews study inferred that changes in perceived fulfilment on needs may sway sustainability of occupant behaviour, the measures of occupant needs are regarded as the independent variables, and the measures of sustainability of behaviours are regarded as the dependent variables through this study. Therefore, the measures Q3_1 to Q3_5 are the independent variables of this section. The dependent variable consisted of the self-reported time duration the lights were used in the room during daylight hours (Q7). In addition, the amount of time the blinds were kept closed during daylight hours was also measured (Q5), since the behaviour emerged to be prevalent from the occupant interview analysis. The floor level of the rooms (Q50) was also included in the analysis given that the researcher considered it a factor with explanatory potential. Finally, since the cross-sectional analysis can only infer correlations and not causation, in order to get a sense of potential causes for behaviours the researcher included questions that allowed occupants to reason their behaviours (Q6, Q9).

Results of correlation analysis

The findings indicate that where the design of sustainable residences satisfies occupants' needs of visual privacy (how far students in the rooms think they can be seen through the windows) and visual comfort (brightness and natural light levels for work), daytime artificial light use is lower. The relationship between visual privacy in the rooms and artificial light use is suggested to be mediated by blind use. Blind use shows significant correlations with both privacy and overheating due to solar gains. Finally, the floor level further nuances the relationships between measures and suggests that higher floor levels might afford better visual privacy and brighter rooms for work possibly resulting in less blind use and artificial light use (see Figure 38).

Visual Privacy, as in how far students in the rooms think they can be seen through the windows, shows a significant negative correlation with daytime artificial light use, with a Spearman's rho (Field, 2016) $\rho = -.246$, $p = 0.000$, meaning that the more private occupants feel the less they use the artificial lights in the room. However, visual privacy is also significantly and negatively correlated with blind use $\rho = -.405$, $p = 0.000$, while blind use is directly correlated with artificial light use as well Pearson's $r = .380$, $p = 0.000$. The correlations suggest that a decrease in privacy is conducive of higher blind use and more extensive blind use also exhibits more artificial light use. Furthermore, 70.7% of respondents confirmed they close the blind to restore their privacy "Table 7. Frequency

table for Reasons of closing blinds during the day.” and 54.1% affirm they use the lights since the blinds are closed “Table 8. Frequency table for Reasons of using lights during the day.”.

Visual Comfort, in terms of harness natural light for work, shows the strongest direct correlation with artificial light use. The more residents report to be able to read a book without the lights on the less number of hours they use the artificial lights, $\rho=-.337$, $p=0.000$. Similarly, brighter rooms are correlated with less light use, $\rho=-.223$, $p=0.001$. Nearly 40% (39.2%) of respondents reason daytime artificial light use with the insufficient light levels even with open blinds “Table 8. Frequency table for Reasons of using lights during the day.”. Interestingly, glare does not correlate with blind use nor with artificial light use, despite the fact that interviews had suggested certain students close the blinds to prevent discomfort glare and 24.3% of respondents state in the questionnaire they close blinds to reduce glare “Table 7. Frequency table for Reasons of closing blinds during the day.”.

Thermal Comfort, more specifically perceived solar gain overheating, also shows correlations with blind use but not with light use. The more occupants feel the sun overheats their rooms blind use tends to slightly increase, $\rho=.153$, $p=0.023$. Closing blinds was justified with trying to reduce overheating by 9.9% of respondents “Table 7. Frequency table for Reasons of closing blinds during the day.”.

Finally, the **Floor level** shows significant correlations with privacy, blind use, and light use. As floor levels increase visual privacy also improves, $\rho=.207$, $p=0.002$, while blind use decreases $r=-.201$, $p=0.003$ just as artificial light use $r=-.134$, $p=0.047$. Furthermore, the higher the floor level the stronger the perceived natural light for work, $\rho=.138$, $p=0.042$ and the stronger the reported overheating $\rho=.185$, $p=0.006$.

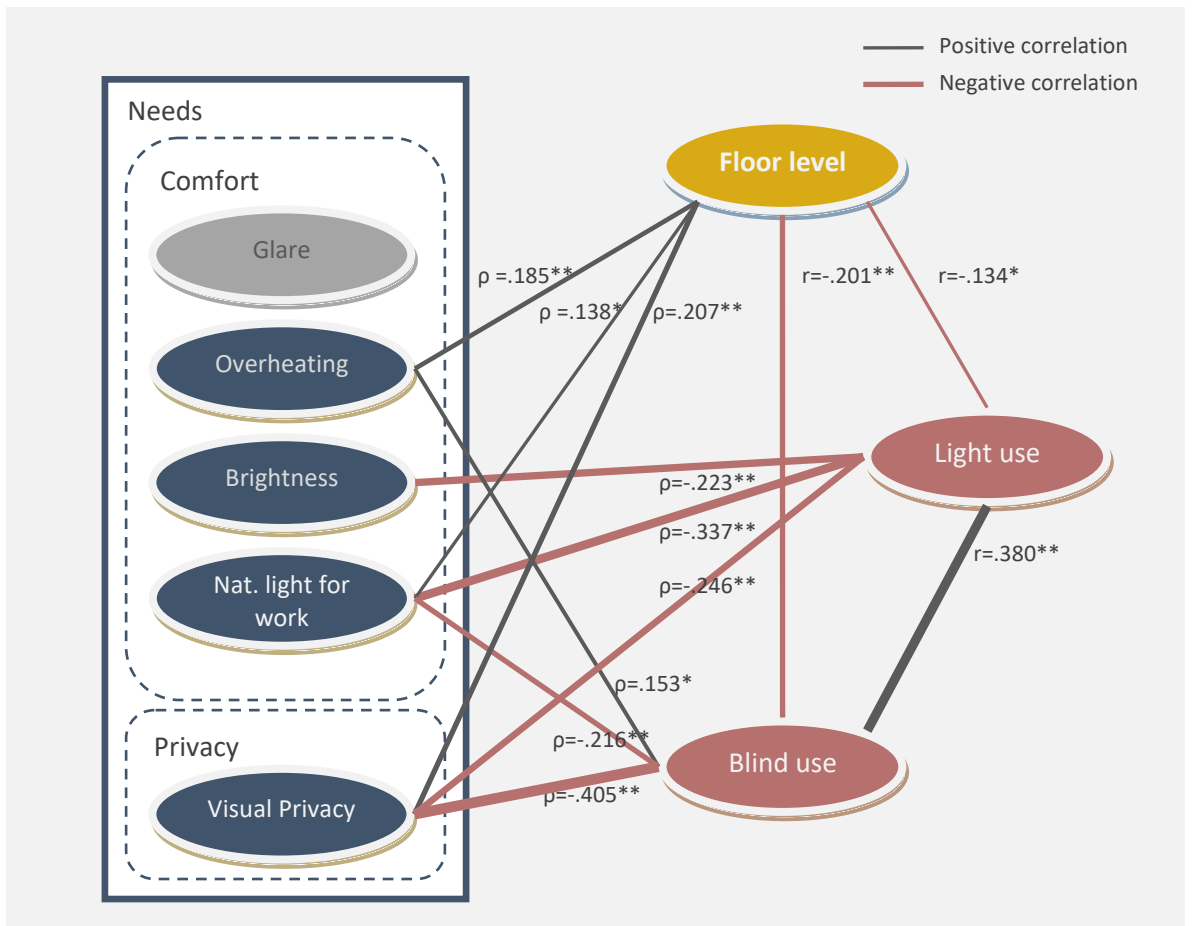


Figure 38. Correlations of Needs - Floor level - Blind use & Light use. * $p < 0.05$; ** $p < 0.01$.

Table 7. Frequency table for Reasons of closing blinds during the day.

Reasons for closing blinds		
Reason selected	No. of Responses	%
People can see into my room	157	70.7%
The sun causes glare	54	24.3%
The sun overheats my room	22	9.9%
Other reasons	36	16.2%

Note: Multiple selections were allowed

Table 8. Frequency table for Reasons of using lights during the day.

Reasons for using lights		
Reason selected	No. of Responses	%
The blinds are closed and the room is dark	120	54.1%
The room is dark even with the blinds open	87	39.2%
The lights are insufficient at the workplace	88	39.6%
Other reasons	6	2.7%

Note: Multiple selections were allowed

5.3.1.1. Results of mean comparisons by Floor level

Data analysis also investigated the relationship of Floor levels, Needs, Blind use and Light use behaviours by comparing means of groups by floor level.

The plot of mean Visual privacy by Floor level suggests that Privacy improves as Floor level increases. However, the increase is only noticeable after the 2nd floor. The Overheating, associated by respondents to solar gain, also increases with the Floor level. Finally, answers suggest that the higher the floor level the better the perceived natural light conditions for work (Figure 38.). Similarly, the plot of mean Blind use and mean Light use by Floor level highlights a decrease in Blind use and Light use as Floor level increases (Figure 40.).

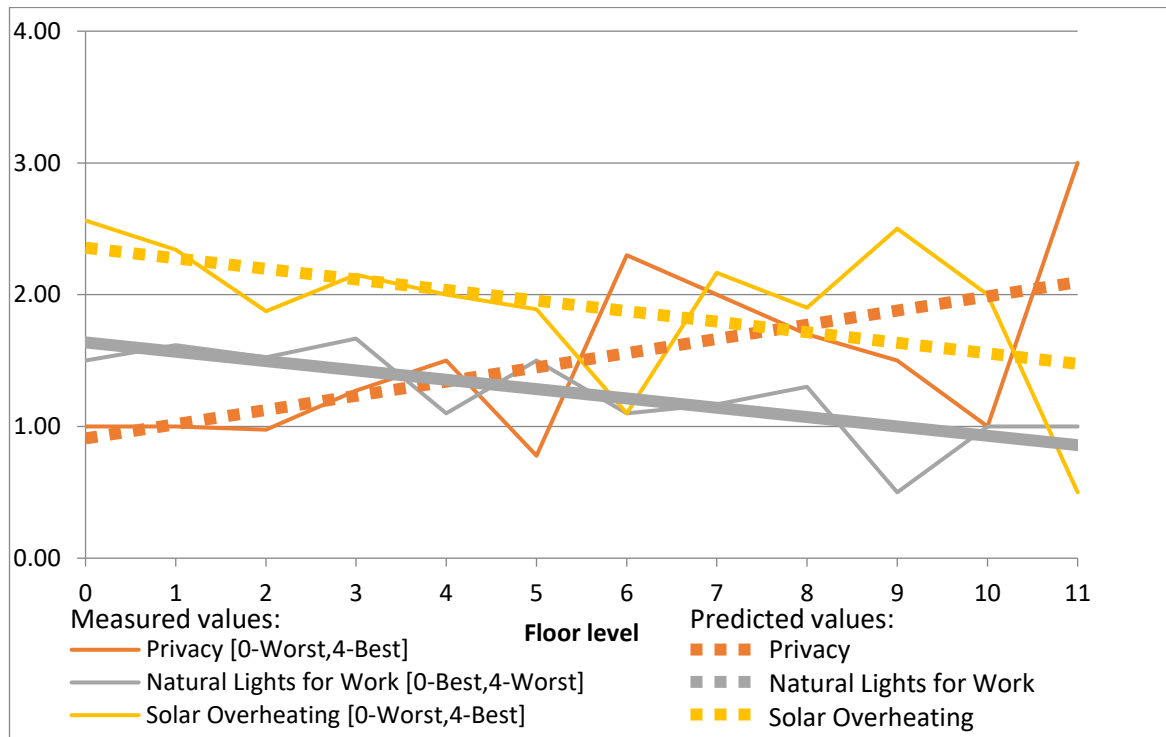


Figure 39. Means of Privacy, Overheating and Natural light level for work by Floor level.

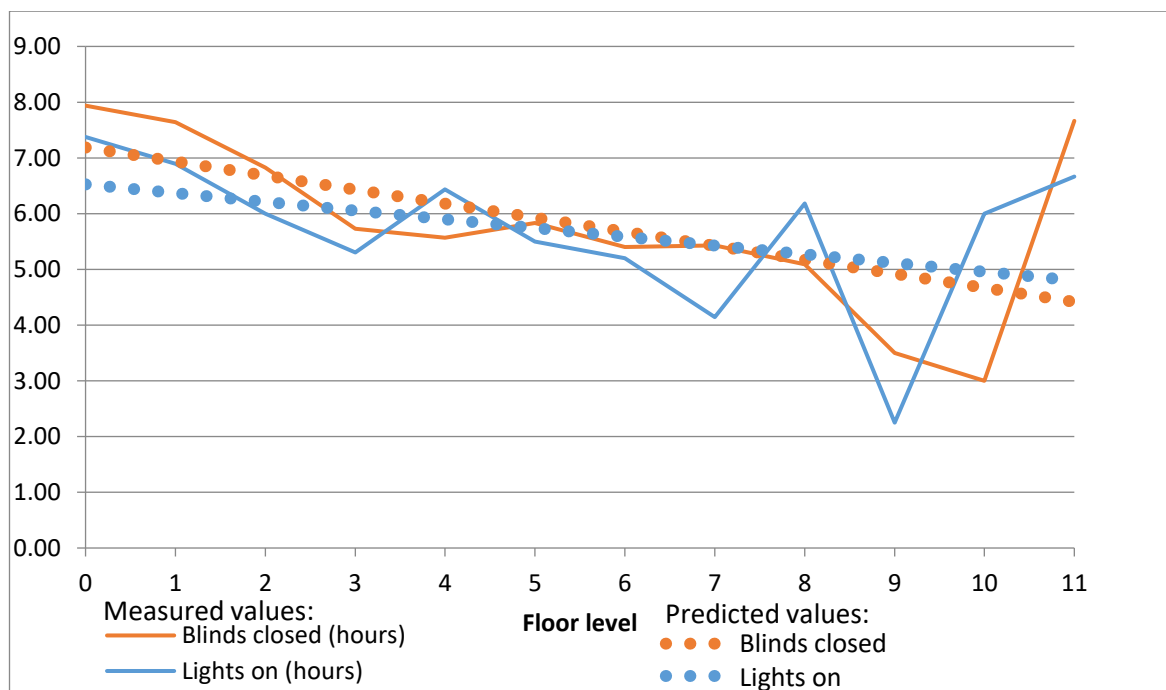


Figure 40. Means of Blind use and Light use by Floor level.

5.3.1.2. Results of the multiple linear regression analysis

To understand how the independent variables together predict the dependent variables multiple linear regressions have been calculated. The following sections present the resulting multiple linear regression models of Blind use and Light use.

Blind use

In the initial model a set of predictors were entered based on the following criteria:

- variables suggested by the occupant interview analysis: Privacy, Glare and Overheating due to solar gains;
- variables considered potential predictors by the researcher: Floor level;
- variables that had significant correlations with Blind use: Privacy, Overheating, Natural light for work and Floor level.

The initially calculated multiple linear regressions showed that not all predictors were significant ($p > .05$). For further refining the model the statistically insignificant predictors were removed in order to reduce model noise. The process was repeated until all remaining predictors were statistically significant.

The final multiple linear regression calculated predicts daytime Blind Use in hours based on Privacy and Floor level. A significant regression was found ($F(2, 215) = 21.819, p < .000$), with $R^2 = .169$, meaning that 16.9% of blind use variance is explained by this model ("Table 9. Blind use - multiple linear regression."). Blind use decreases by 0.3 hours as floor levels increase, and decreases by 1.07 hours as perceived privacy improves. Privacy is coded on 5-point Likert-scale from 0-High privacy and 4-Poor privacy and Floor level is the floor number on which participants live with a minimum value of 0 and a maximum value of 11. Both Privacy and Floor level is a significant predictor of Blind use.

Table 9. Blind use - multiple linear regression.

Blind use - Multiple linear regression				
Variable	B	SEB	β	p
Constant	8.616	0.457		.000
Privacy	-1.070	0.203	-.335	.000
Floor level	-0.300	0.108	-.177	.000
$R = .411, R^2 = .169, p < .000, N = 218.$				

B - unstandardized coefficient for the linear regression equation; SEB - Standard Error of B; β - The standardized regression coefficient; p - probability value.

Light use

In the initial calculations a set of predictors were entered based on the following criteria:

- variables suggested by the student interviews: Brightness, Blind use;
- variables considered potential predictors by the researcher: Floor level;
- variables that had statistically significant correlations with Light use: Brightness, Natural light for work, Blind use, Privacy, and Floor level.

The calculated multiple linear regression showed that not all predictors were statistically significant ($p > .05$). For further refining the model and in order to reduce noise the insignificant predictors were gradually removed. The process was repeated until all remaining predictors were statistically significant.

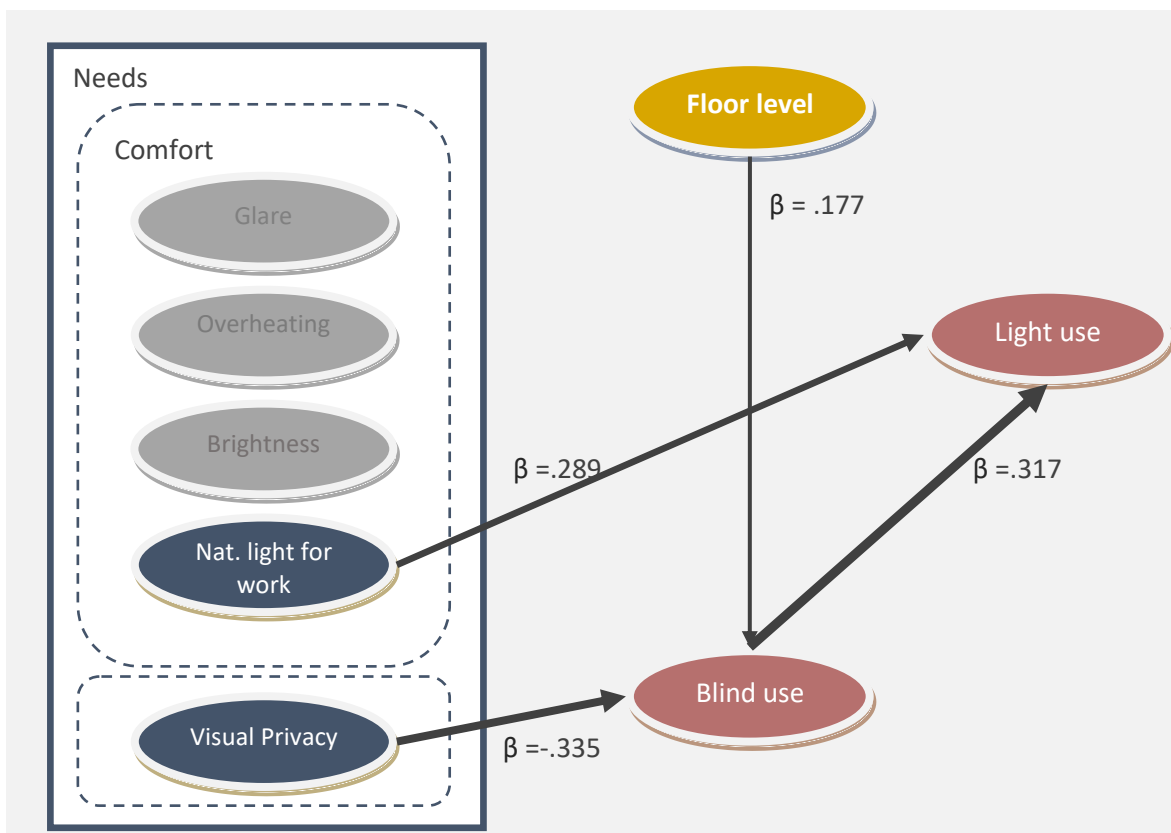


Figure 41. Multiple Linear Regression for predicting Blind use and Light Use. β –standardized coefficients

The final multiple linear regression model predicts daytime Light use in hours based on Comfort (perceived natural light levels for work) and Blind use (“Table 10. Light use - multiple linear regression.” and Figure 41). A significant regression was found ($F(2, 219) = 31.526, p < .000$), with $R^2 = .224$, explaining 22.4% variance in light use. Light use hours increase by 1.02 hours as perceived light levels for work decrease by one unit, and increase by 0.31 hours for each hour of Blind use. Light levels for work is coded on 5 point Likert-scale from 0-Good light levels and 4-Poor light levels and Blind use is measured in hours. Both Light levels and Blind use were significant predictors of Light use.

Table 10. Light use - multiple linear regression.

Light use - Multiple linear regression				
Variable	B	SEB	β	p
Constant	2.560	0.508		.000
Light level for work	1.023	0.216	.289	.000
Blind use	0.317	0.061	.317	.000

$R = .473, R^2 = .224, p < .000, N = 218.$

B - unstandardized coefficient for the linear regression equation; SEB - Standard Error of B; β - The standardized regression coefficient; p - probability value.

5.3.1.3. Discussion and Conclusion

The studies suggest that up to 22% of the variance in artificial light use in student rooms may be explained by how far needs such as visual privacy and visual comfort are supported by the built environment. Residents use artificial lights across the day for various purposes; however it can be argued that the extent of light use can be mitigated by design to a significant degree.

Visual privacy (Altman, 1975), is of outstanding importance in student accommodations since the room is often the only private space occupants have. Therefore, residents are highly protective of privacy and employ various coping strategies to restore it (Amole, 2005). In the studied cases, residents closed the blinds to feel more private and subsequently turned on the lights. Efforts to regain privacy burdens occupants' physiology and psychology (Altman, 1975) while the lack of natural light might also be detrimental to health, well-being and performance (An et al., 2016; Stone, 1999). However, what is relevant from an environmentally significant behaviour perspective and what the study reveals is that the less visual privacy the design affords the more energy intensive consequences the coping mechanisms have. Therefore, considering visual privacy in student rooms is crucial when designing sustainable buildings that promote less energy intensive behaviours while supporting health, well-being and performance. Even more so, since in the investigated buildings 69% of residents felt their privacy was compromised.

Regarding visual comfort, the main finding is not that lower levels of natural light for work are associated with more intensive artificial light use; that is obvious. Instead, the findings underline the importance of considering this specific aspect of visual comfort in the context of student bedrooms. Especially that student bedrooms are multifunctional spaces accommodating various activities, including work. Thus, design that caters for visual comfort for work in student bedrooms also promotes more energy considerate behaviours. Given that less than 25% ("Table 27. Perceived brightness of the room.") of the students reported to have insufficient natural light for work, it can be concluded that the studied accommodations were fairly supportive of student needs, however there is still room for improvement.

The floor level of student rooms showed significant relationships with student needs and blind use and light use behaviours. This phenomena can be interpreted as a demonstration on how a design feature, in the present case floor level, might positively affect visual privacy and available natural light levels for work leading to more environmentally beneficial artificial and natural light use patterns. The interpretation of student interviews suggested further design features that could help improve visual privacy and reduce blind use and light use. Adequate distance between adjacent buildings, well-designed pedestrian paths in the context of sightlines into student rooms, use of appropriate vegetation in front of the windows, well-designed shading devices that can moderate visibility without excessively reducing natural lights, dual blind systems that incorporate black-out blinds and translucent blinds, interior design and furniture arrangements that is aware of sightlines, to name but a few.

The right solutions to protect visual privacy and ensure natural light level for work should be based on careful consideration of the context of interest. While visual privacy is important in all student rooms, special attention should be given to rooms located on the lower floors since based on the findings of the present research they are more prone to visual privacy issues than rooms on the upper floors. Here it is important to mention that, based on participant narratives, the buildings that were higher than five floors did not have any surrounding buildings close enough to compromise visual privacy. Were the surrounding buildings built excessively close to the studied accommodations, visual privacy issues could have occurred on upper floors as well.

5.3.2. Light use behaviour in kitchen and living areas

Light use behaviours in the kitchen and living areas of the student flats were suggested by the interviews to be driven by the type of control occupants had over lights and the visual comfort the space affords (Figure 43).

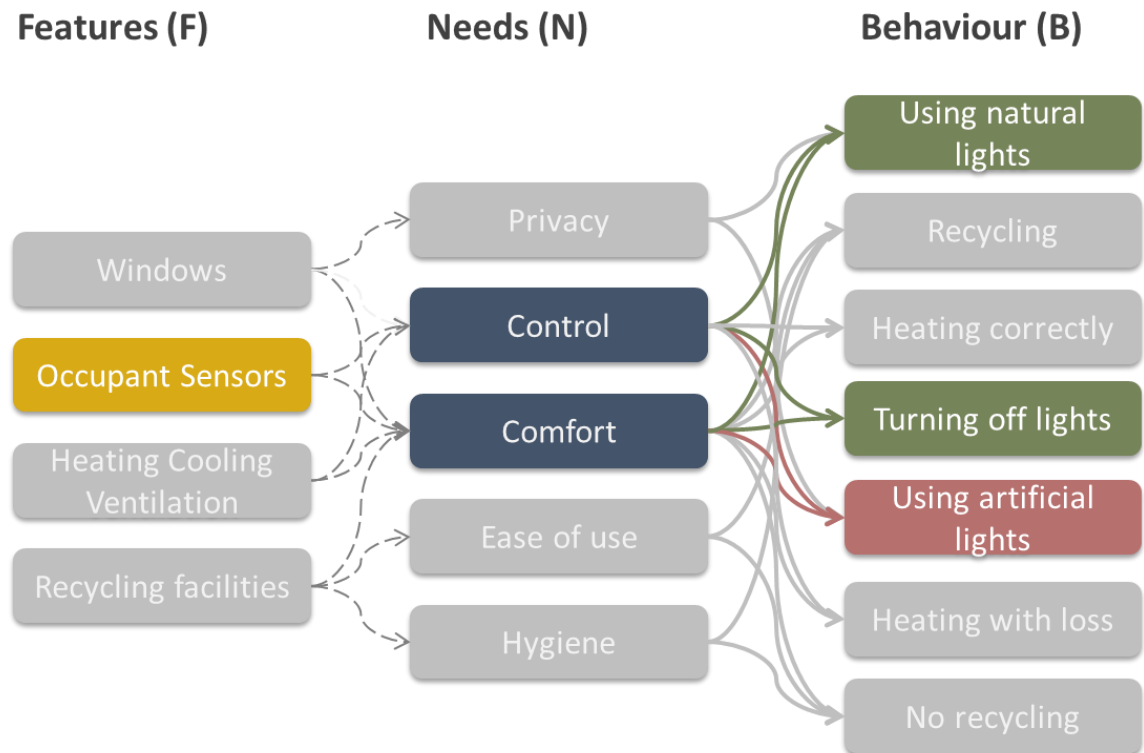


Figure 43. Kitchen light use related Feature-Need-Behaviour map as inferred from occupant interviews.

Kitchen and living areas in the flats of the studied accommodations are accommodated by same space, therefore the study of light use in the kitchen areas overlaps with the study of light use in living areas. In the present study, control is measured by prompting for the type of light control strategy available in the kitchen area (Q12), while visual comfort is measured by the perceived brightness of the space (Q10). These two measures constitute the independent variables of this section. The outcome variable, i.e. related environmentally significant behaviour, is measured through the self-reported amount of time artificial kitchen lights are on during daylight hours (Q11_1). Floor level (Q50) relationship with light use is also explored since it was related to room light use in the previous section. Finally, reasons for using the lights in the kitchen during the day is also prompted for (Q13).

5.3.2.1. Results of the analysis

In some of the accommodations, the kitchen was not equipped with manual light switch, and subsequently occupants had no agency over the light use. Therefore, their data was excluded

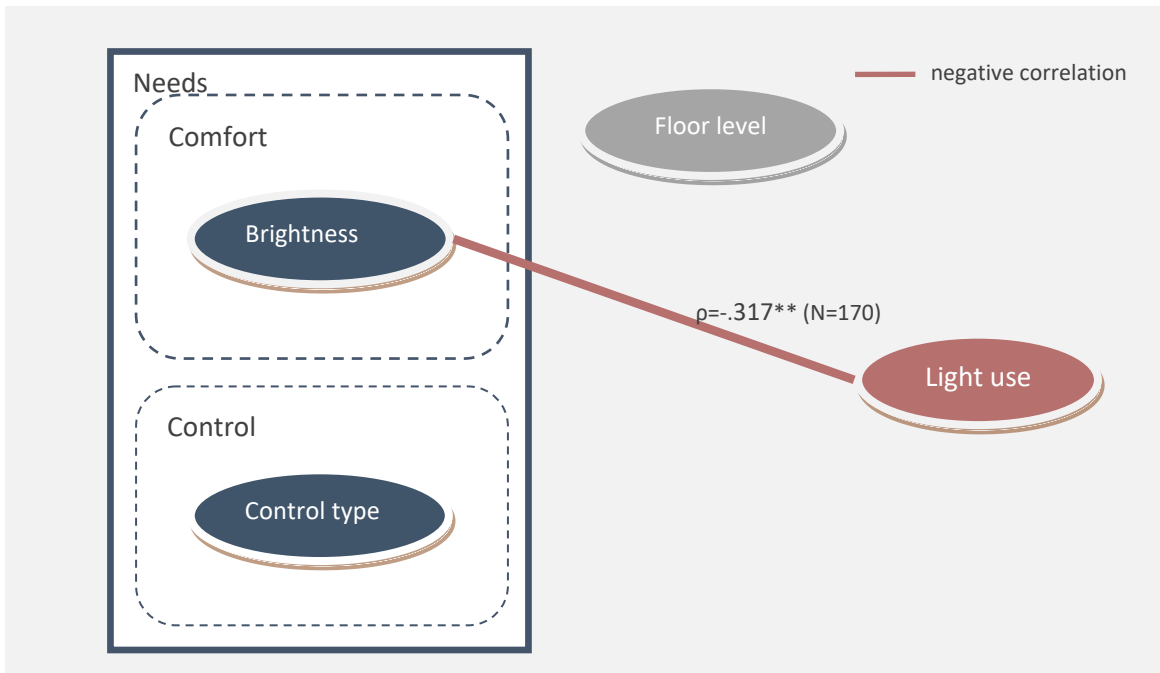


Figure 44. Correlations of Needs - Kitchen light use. * $p < .05$; ** $p < .01$.

from the analysis of relationship between brightness and lights use. Spearman’s rho was calculated on the remaining N=170 responses to explore the aforementioned relationship. The results revealed significant correlations between brightness and light use with $\rho = -.317$, $p = 0.000$, suggesting that as brightness of the kitchen increases light use decreases. Floor level and perceptions of brightness or light use correlations were calculated however, these were weak and not statistically significant.

There were three types of light controls in the kitchens/living areas of the studied accommodations: Passive Infra-Red (PIR) sensor only with no manual control, manual only control, and dual control (manual and PIR). In order to grasp the relationship of light controls and light use a comparison of the means was performed using one-way ANOVA. The results “Table 11. Kitchen light use by Control type – One-way ANOVA.” suggest that light controls define significantly different groups in terms of light use.

Table 11. Kitchen light use by Control type – One-way ANOVA.

ANOVA Table – Kitchen light use by Control type						
		Sum of Squares	df	Mean Square	F	Sig.
Between Groups	(Combined)	178.491	2	89.245	4.775	.009
Within Groups		4093.347	219	18.691		
Total		4271.838	221			

Comparison of means suggests that fully automatic controls have the highest artificial light use while dual control light systems are the least energy intensive, presenting on average 2 hours less light use during daylight hours (see Figure 45.) than the fully automatic case.

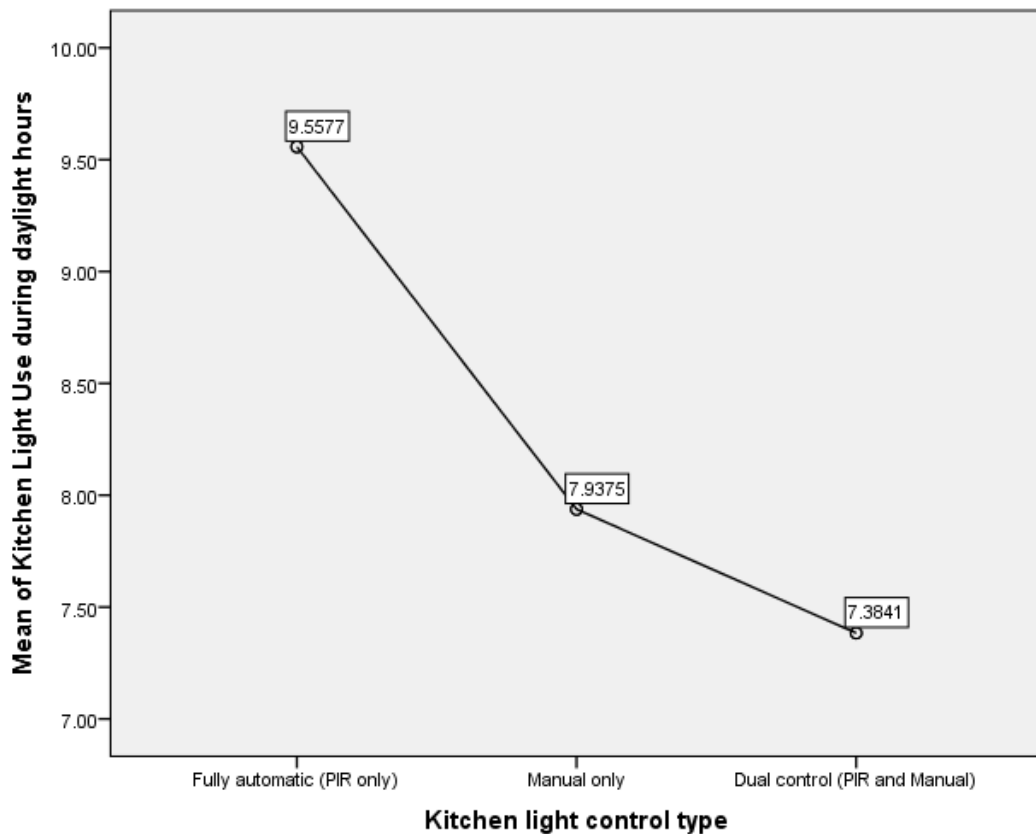


Figure 45. Mean light use by Control type.

The difference between the most energy intensive (fully automatic) and least energy intensive (dual controls) groups was found to be statistically significant at $p=.006$.

Table 12. Light use by Control type - Tukey's HSD.

Multiple Comparisons of Kitchen Light use with Tukey's HSD				
Kitchen light controls	Kitchen light controls	Mean Difference (hours)	Std. Error	Sig.
Fully automatic	Manual only	1.62	.97136	.220
	Dual control	2.17*	.70348	.006
Manual only	Fully automatic	-1.62	.97136	.220
	Dual control	.55	.84826	.791
Dual control	Fully automatic	-2.17*	.70348	.006
	Manual only	-.55	.84826	.791

When asked for the reasons of having the kitchen lights on during the day, respondents suggest lack of control 23.9%, insufficient light levels 34.2%, other flatmates use the lights 52.7% and other reasons 6.3% (see "Table 13. Reasons for using the kitchen lights during the day.").

Table 13. Reasons for using the kitchen lights during the day.

Reasons for using kitchen lights		
Reason selected	No. of Responses	%
Other flatmates	117	52.7%
Insufficient light levels	76	34.2%
Lack of control	53	23.9%
Other reasons	14	6.3%

Note: Multiple selections were allowed

77% (171 responses) of occupants also report wanting to switch off or dim the lights while in the kitchen during the evening (Q14). They reason this expectation with various activities performed in the kitchen during the evening as follows (Q15):

Table 14. Evening time activities requiring reduced lighting.

Evening activities in kitchen necessitating low or no lights		
Activity	No. of Responses	%
Flat partying	108	48.6%
Hanging out with friends	94	42.3%
Watching movies	56	25.2%
Playing video games	38	17.1%

Note: Multiple selections were allowed

However, when occupants do not have control over the lights they resort to circumventing the automatic system. Thirty-one occupants, that is 60% of the 52 respondents who had no control over the lights, reported to tape the sensors in order to have the lights off during evening hours (Q17). Residents also reported the frequency of their reduced light level-requiring evening activities (Q16) as follows:

Table 15. Frequency of evening activities that require reduced lighting.

Frequency of activities	No. of Responses	%
Less than twice a month	59	26.6%
2-4 times a month	67	30.2%
5-9 times a month	49	22.1%
More than 10 times a month	31	14.0%
Total	206	

5.3.2.2. *Discussion and Conclusion*

The results of the correlational analysis supports the inferences of the interview studies by revealing statistically significant relationships between artificial light use in living/kitchen areas of student accommodations and visual comfort, that is, perceived brightness of the space. Furthermore, the comparison of the three types of control conditions over light use (fully automatic, manual, and automatic and manual) in the living/kitchen areas yields statistically significant group differences. Based on the analysis, it can be argued that the kitchen light use can be moderated by the way the design considers the perceived brightness of the space and the type of control over the lights.

In terms of visual comfort, the brighter residents perceive the kitchens, the shorter the reported artificial light use hours are. Therefore, the perceived brightness of the space is suggested to be an important factor contributing to the light use behaviours in the living rooms of sustainable accommodations. Overall, the designs of the studied residences were found to be rather considerate of this factor since about 75% of residents reported to have bright kitchens without the lights on.

Control over the lights was another significant factor that was linked to daytime artificial light use in the kitchen areas. The results revealed that in some of the sustainable accommodations the implemented light control strategies were fully automatic, restricting resident's actions and limiting choice over light use. However, during the interviews, residents often expressed desire to turn the lights off during the day. Earlier studies also indicate that occupants prefer to have manual control over the lights even when automatic light control systems are in place (Aghemo et al., 2014; Escuyer & Fontoynt, 2001; Galasiu & Veitch, 2006). Furthermore, the lack of control over the indoor environment may generate lower comfort and satisfaction levels (Frontczak & Wargocki, 2011). From an environmental perspective, the comparison of mean light use values underlines that the lack of occupant agency over the lights results in longer light use hours. This happens because the lights are controlled by occupant sensors and turn on every time occupants enter the space, however, the system is not sophisticated enough to adjust to the changing natural light conditions. On the other side, when the kitchens are equipped with dual controls and residents can exert agency over lights, the accompanying behaviour is less energy intensive.

Considering and providing agency over the lights in the living rooms and kitchens of sustainable accommodations is not only important during the day. These areas are stages for diverse activities during the evening as well. Residents reported in their interviews to use these spaces for preparing meals, reading and learning, social gatherings, and for performing various leisure

activities. Preference for reduced light levels that would better support these activities was also reported. The quantitative study further supports with descriptive data the popularity and frequency of leisure activities that require dimmed or no lights (see Table 15. Frequency of evening activities that require reduced lighting.). Furthermore, the data shows that where control systems are restrictive of occupant control, systems are circumvented by 60% of residents in order to support the evening activities being performed. In the present case the circumventing behaviour leads to lower energy use however, according to participant recounts, it compromises comfort.

Activities in communal kitchen/living areas could all benefit from well-designed illumination beyond the simple light switch or basic fully automatic controls. In the scenarios where occupants would only want lower light levels in support of their evening activities, dimmable lights might allow for less energyvorous light use while increasing residents' comfort. Activity based lighting could also reduce the energy intensity of light use since needs for appropriate lighting would be better supported during the night and day alike. It is, therefore, the contention of this study that understanding and responding by design to lighting needs raised by occupant comfort and control expectations may be conducive of more sustainable light use behaviours in the kitchen and living areas of sustainable residences.

5.3.3. Heating behaviours in the rooms

The student interviews suggested a number of factors that may predict heating behaviours in the studied accommodations. Comfort in terms of Thermal comfort and Perceived air quality and Control emerged as a key factor driving occupants' heating practices. The present study investigates and discusses only the relationship of comfort and heating practices. Control was not included in the survey study due to space limitations of the questionnaire.

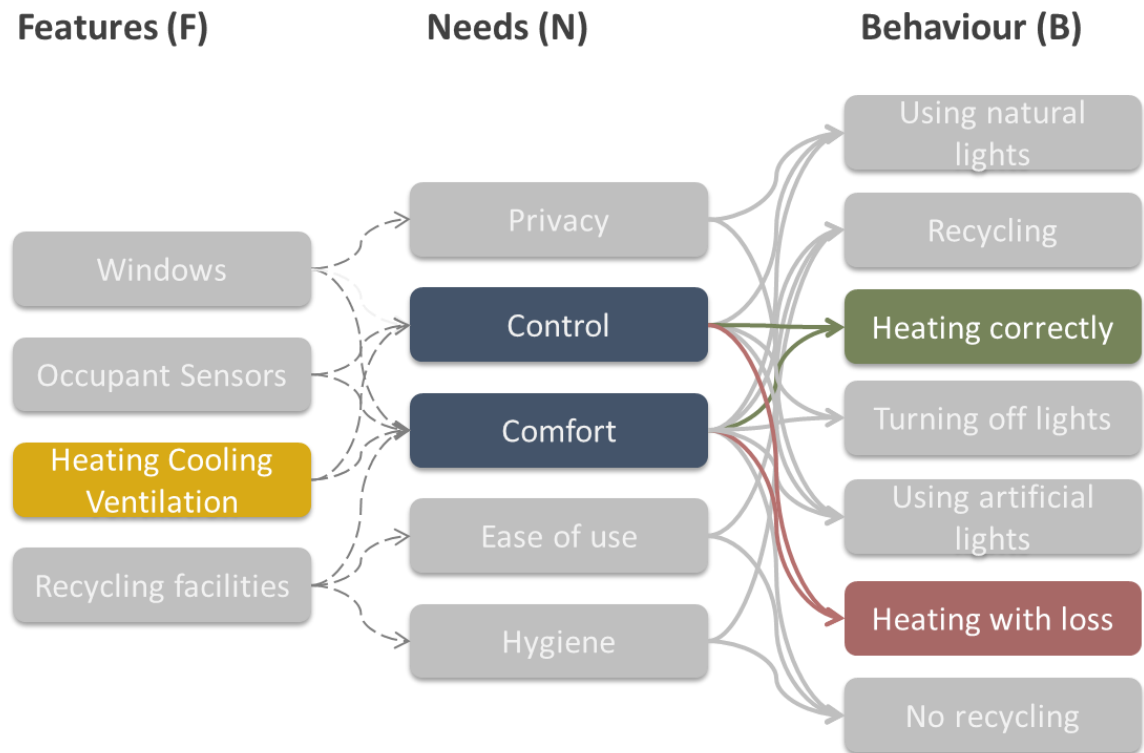


Figure 46. Heating related Feature-Need-Behaviour map inferred from occupant interviews.

The quantitative study aimed to understand how four comfort components - perceived room temperature (Q18), air humidity (Q22), airflow (Q23) and air freshness(Q24) - may serve as a predictors of heating behaviours, and were regarded therefore as the independent variables. The heating practices, regarded as outcome variables, were investigated by prompting for duration of radiator use(Q19) and for radiator settings (Q20). The study also explored how heating with open windows (Q26), which was a prevalent behaviour in the occupant interviews, relates to overall heating duration and intensity. In addition, the study prompted for reasons of performing the behaviour of heating with open windows (Q27).

Results of the correlational analysis

Heating duration and heating intensity shows statistically significant correlations with two components of comfort, namely perceived temperature and air humidity. The colder the rooms

are perceived the higher the heater use duration ($\rho=.280$, $p=.000$) and radiator setting ($\rho=.319$, $p=.000$). Similarly, the more dry the air was perceived the higher the heater use duration ($\rho=.232$, $p=.001$) and radiator setting ($\rho=.190$, $p=.007$). Heating time and heating setting are also significantly correlated suggesting those who use the heaters for longer also use them at higher settings ($r=.605$, $p=.000$). Furthermore, heating with open windows shows significant correlations with both heating time ($r=.262$, $p=.000$) and radiator settings ($r=.180$, $p=.011$). Perceived air flow and air freshness in the room were not correlated with any of the measured dimension of the heating practices, and none of the measured comfort components were correlated with the duration of heating with open windows. Finally, floor level showed an inverse correlation with heating duration, suggesting residents living on higher floors use the radiators for shorter times ($r=-.164$, $p=.021$).

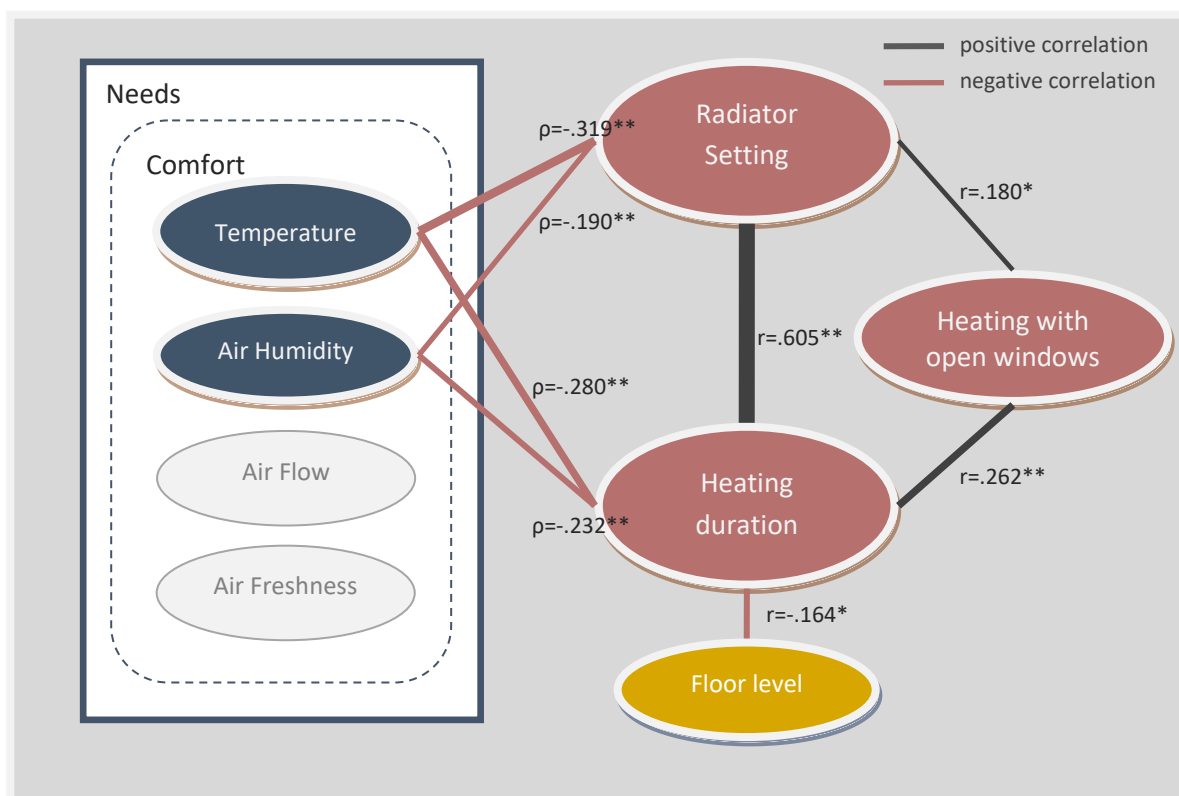


Figure 48. Correlations for Comfort needs and Heating practices. * $p < 0.05$; ** $p < 0.01$, $N = 200$.

5.3.3.1. Results of the explorative multiple linear regression analysis

In order to assess how the discussed factors together may predict heating duration and heater settings, multiple linear regression models were built using all comfort measures, heating with open window measure, and floor level as predictors. As a refinement to the models, the factors that were not statistically significant ($p > .05$) were gradually removed from the models.

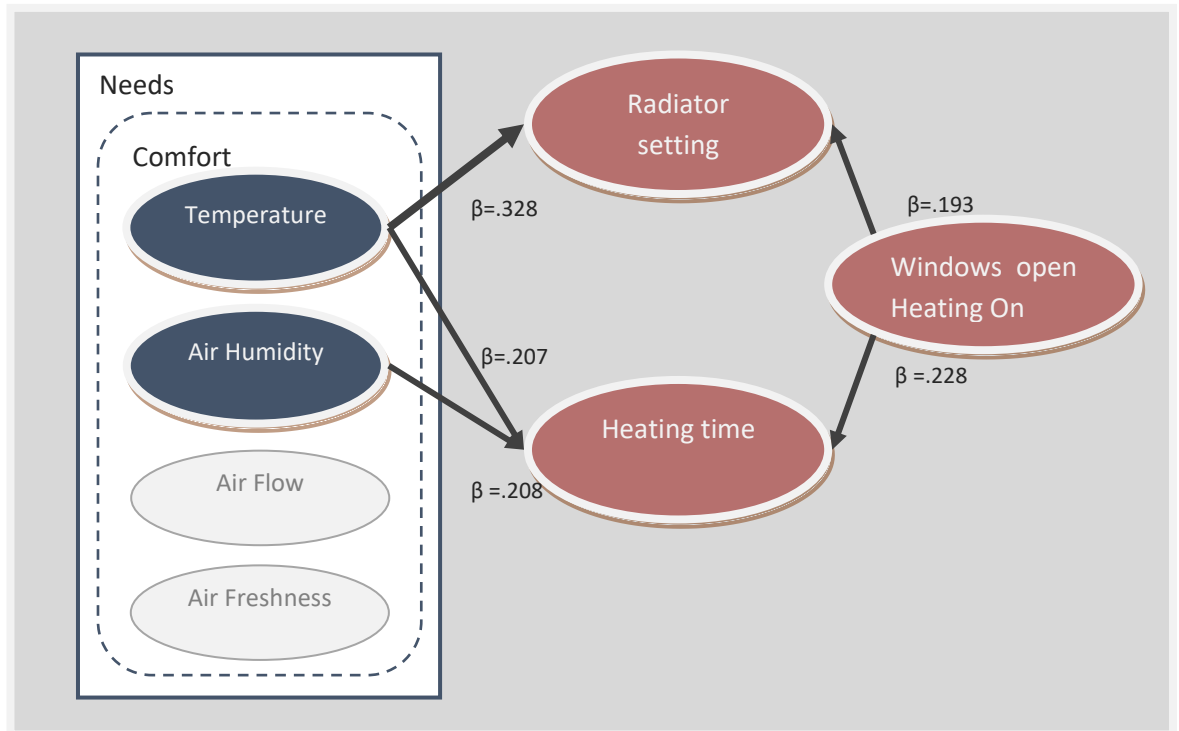


Figure 49. Multiple linear regressions for predicting Heating practices. β -Standardized coefficients.

Eventually, the calculated multiple linear regressions predict:

- Heating time based on perceived temperature, air humidity and the time windows are open while heating is on; and
- Radiator setting based on perceived temperature and the time windows are open while heating is on.

For heating time, a significant regression was found ($F(3, 207) = 12.460, p < .000$), with an R^2 of .153, meaning that 15.3% of the variance in heating time is explained by this model. Heating time increases by 1.39 hours as perceived temperature decreases, where perceived temperature was coded on 5 point Likert-scale from 0-Very hot to 4-Very cold; by 1.70 hours as the air is perceived more dry, where air humidity was coded on 5 point Likert-scale from 0-very humid to 4-very dry; and by 0.48 hours for every hour the window is open while the heating is on (see Table 16. Heating time - Multiple linear regression.).

Table 16. Heating time - Multiple linear regression.

Heating time - Multiple linear regression				
Variable	B	SEB	β	p
Constant	2.173	1.387		.119
Temperature	1.392	.439	.207	.002
Humidity	1.705	.536	.208	.002
Window Open & heating On	.478	.134	.228	.000

$R = .391, R^2 = .153, p < .000, N = 211.$

B - unstandardized coefficient for the linear regression equation; SEB - Standard Error of B; β - The standardized regression coefficient; p - probability value.

For radiator settings, a significant regression was found ($F(2, 209) = 17.102, p < .000$), with an R^2 of .141, explaining 14.1% of the variation in heating settings. Radiator setting was coded from 0-Off to 6-Max setting, perceived temperature was coded on 5 point Likert-scale from 0-Very hot to 4-Very cold and the time windows are open while the heating is on is expressed in hours. The model suggests that students who perceive the room as the coldest use the radiator at a higher setting by 2.5 units than those who feel their rooms are very warm. Moreover, keeping the windows open while the heating is on also predicts higher radiator settings (see Table 17. Multiple linear regression - Radiator setting.).

Table 17. Multiple linear regression - Radiator setting.

Radiator setting - Multiple linear regression				
Variable	B	SEB	β	p
Constant	1.552	.288		.000
Temperature	.640	.125	.328	.000
Window Open & heating On	.118	.039	.193	.003

$R = .375, R^2 = .141, p < .000, N = 212.$

B - unstandardized coefficient for the linear regression equation; SEB - Standard Error of B; β - The standardized regression coefficient; p - probability value.

Students were also prompted to reason why they engaged in keeping the windows open while the heating was on. Surprisingly, more than half of the students (113 responses, which is 50.9%) reason their action with poor air quality (stiffness). A further 23.9% name overheating due to radiators as the main reason, while 18.0% keep the window open by habit (see Table 18. Reasons for heating with open windows.).

Table 18. Reasons for heating with open windows.

Reasons for opening windows while heater is on		
Reason	No. of Responses	%
The air is stuffy with closed windows	113	50.9%
The radiator causes overheating	53	23.9%
Habit of keeping the window open	40	18.0%
Other reasons	11	5.0%

Note: Multiple selections were allowed

Although correlations between perceived air quality and heating with open window practices was not statistically significant in the present data set, the most popular reasoning used by residents to explain heating with open windows called for further investigations. Responses were divided in two groups depending on whether respondents marked the stuffy air as a reason for the maladaptive behaviour of heating with open windows. ANOVA tests were used to compare:

- the mean of perceived air freshness between the two groups;
- the mean of heating time while the window is open between the two groups.

The ANOVA test indicates the groups have statistically significantly different mean values ($F(1,218)=27.157$, $p=.000$) for perceived air freshness. The mean perception of air freshness for the group who reasons the energy detrimental heating behaviour with air stuffiness is significantly more indicative of stuffy air (see Table 19. Mean comparison of perceived air freshness.).

Table 19. Mean comparison of perceived air freshness.

Air Freshness perception - Group means by reasoning					
Reasoning	N	% of Total N	Mean *	Std. Deviation	Std. Error of Mean
0	109	49.3%	1.82	.894	.086
If I close the window the air is stuffy	112	50.7%	2.19	1.070	.101
Total	221	100.0%	2.00	1.002	.067

*Air freshness is measured on 5 point Likert-scale: 0-Very Fresh air, 4- Very Stuffy air

Table 20. ANOVA test for air freshness.

ANOVA Table – Air Freshness perception by Reasoning with stuffy air					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.603	1	7.603	7.802	.006
Within Groups	213.393	219	.974		
Total	220.995	220			

Furthermore, the ANOVA test indicates the groups have statistically significantly different mean values ($F(1,218)=27.157$, $p=.000$) for heating time with open windows as well. The group reasoning its action with poor air quality heats with open windows for almost 2 hours (3.24 h – 1.31 h) more on average (see Table 21. Mean comparison of heating with open windows.).

Table 21. Mean comparison of heating with open windows.

Duration of Heating with open windows - Group means by reasoning					
Reasoning	N	% of Total	Mean (hours)	Std. Deviation	Std. Error of Mean
0	108	49.1%	1.31	2.253	.217
If I close the window the air is stuffy	112	50.9%	3.24	3.163	.299
Total	220	100.0%	2.29	2.914	.196

Table 22. ANOVA test for heating time with open windows.

ANOVA Table – Heating with open window by Reasoning with stuffy air					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	205.974	1	205.974	27.157	.000
Within Groups	1653.408	218	7.584		
Total	1859.382	219			

5.3.3.2. Discussion and conclusion

The statistical analysis supports that heating practices in student rooms do relate to two main aspects of Comfort needs: Perceived temperature and Perceived air quality. Both of these aspects are correlated with two dimensions of heating practices: heating time and radiator setting. Considering the correlational results in conjunction with the interview analysis, it can be argued that heating practices can be swayed towards more sustainable directions by design solutions that ensure satisfactory thermal environment and air quality.

Thermal comfort has a greater importance for residents than any of the other indoor environment related comfort dimensions and has the biggest impact on satisfaction (Frontczak & Wargocki, 2011). In the present study perceived temperature also emerged as the strongest predictor of how heating practices unfold in student rooms. The results of the statistical analysis further revealed what components of heating practices relate to thermal comfort. The higher the perceived temperature the lower the reported heating hours and the lower the reported heating settings in student rooms. Descriptive data shows that in the studied cases less than half of the student population (43.7%) perceived the temperature neither hot nor cold, while 28.8% reported to have hot environments and 27.5% reported to have cold rooms.

Perceived air quality was another important factor relating to the energy use during heating practices in student rooms. The study focused on three aspects of perceived air quality: humidity, freshness and airflow. The analysis revealed that residents' perception on air humidity was negatively correlated with the heating hours and the heating intensity. The drier the air was perceived by respondents the more time they kept their radiator on using higher settings.

Beyond examining relationships between occupant needs and overall heating behaviour the study also aimed to further understand the energy wasteful behaviour of heating with open windows. Earlier studies mention heating with open windows as a behaviour observed in student accommodations, employed to regulate the thermal environment (Clear et al., 2015). The qualitative analysis of student interviews suggested the behaviour might also be driven by poor air quality. However, the correlational analysis did not find any relationship between perceived air quality and the behaviour in question. Nevertheless, when respondents were asked to name the

reasons behind the energy intensive behaviour of focus, more than 50% reported the air was stuffy with closed windows. Furthermore, the same group was found to keep the window open while heating for significantly longer time, by almost two hours on average, than the remaining part of the respondents. Understanding the drives of heating with open windows is especially important for the design of sustainable accommodations since two thirds of all residents of the studied accommodations report to perform the action.

It has been acknowledged that indoor environmental qualities may drive occupant comfort and satisfaction, and may influence health, well-being and performance. Efforts to regain comfort may impose further strain on occupants. Sustainable buildings are generally expected by common sense to provide more comfortable indoor environments. However, the literature on the topic of indoor environmental qualities in sustainable buildings is equivocal. Some studies bring support for how buildings with green certificates promote higher environmental satisfaction (Leder et al., 2016) . Others contrast this perspective and advocate that green certified buildings provide no less or more satisfaction in regard to the indoor environmental quality than their more conventional equivalents (Altomonte & Schiavon, 2013). The present study gathered data on the perceived thermal comfort and air quality afforded by sustainably designed student residences and also presents the energy relevant behavioural implications of residents mitigating their discomfort. In the studied sustainable environments more than 56% of respondents perceived their rooms either as hot either as cold, about 37% felt the air was either humid either dry, and 35% felt their room had stuffy air in general. In an attempt to restore comfort residents who perceive the rooms as cold report heating more intensively overall. While those who experience the air as stuffy with closed windows, open the window while the heating is on for longer periods, wasting significant heating energy.

5.3.4. Waste management practices in student flats and communal areas

The occupant interviews suggested the needs that govern recycling are comfort, in the sense of physical proximity of bins, perceived as ease of use, and hygiene.

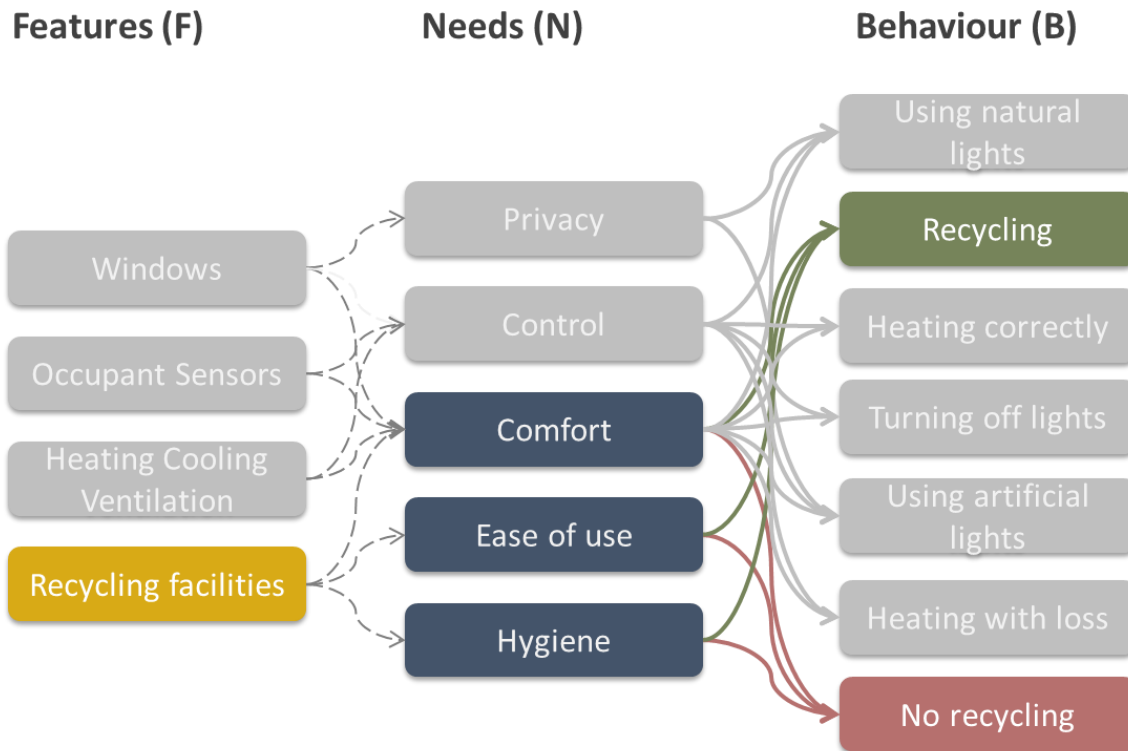


Figure 50. Waste management related Feature-Need-Behaviour map as inferred from occupant interviews.

Therefore, Comfort is measured through the presence of recycle bins in the rooms (Q28); Ease of use is measured through visual differences between waste bins from the kitchen area of student flats (Q29) and through the perceived ease of use when interacting with the recycle bins (Q30); while Hygiene is measured by the perceived cleanliness of using the recycle bins (Q31). These are considered the independent variables of this section based on logic described in earlier sections. The behaviours of interest, the dependent variables, are the frequency of recycling in rooms (Q35_1), and the combined frequency (Q35_2) and correctness of recycling practices in the kitchen (Q36).

5.3.4.1. Results

The comparison of means frequencies for recycling show that students who reside in rooms equipped with recycle bins recycle significantly more often in their room ($F(1,220)=28.694$, $p=0.000$) than those without a recycle bin in their room.

Table 23. ANOVA test for Recycling frequency by presence of bins in rooms.

ANOVA Recycling frequency by Presence of recycle bin in the rooms					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	32.235	1	32.235	28.694	.000
Within Groups	247.152	220	1.123		
Total	279.387	221			

Table 24. Mean of recycling frequencies in the room.

Mean recycling frequency in rooms by Presence of recycle bin in the room					
Recycle bin in the room	N	% of Total N	Mean *	Std. Deviation	Std. Error of Mean
No	175	78.8%	1.72	1.102	.083
Yes	47	21.2%	0.79	.883	.129
Total	222	100.0%	1.52	1.124	.075

* Recycling frequency in room: [0=always, 1=often, 2=occasionally, 3=never]

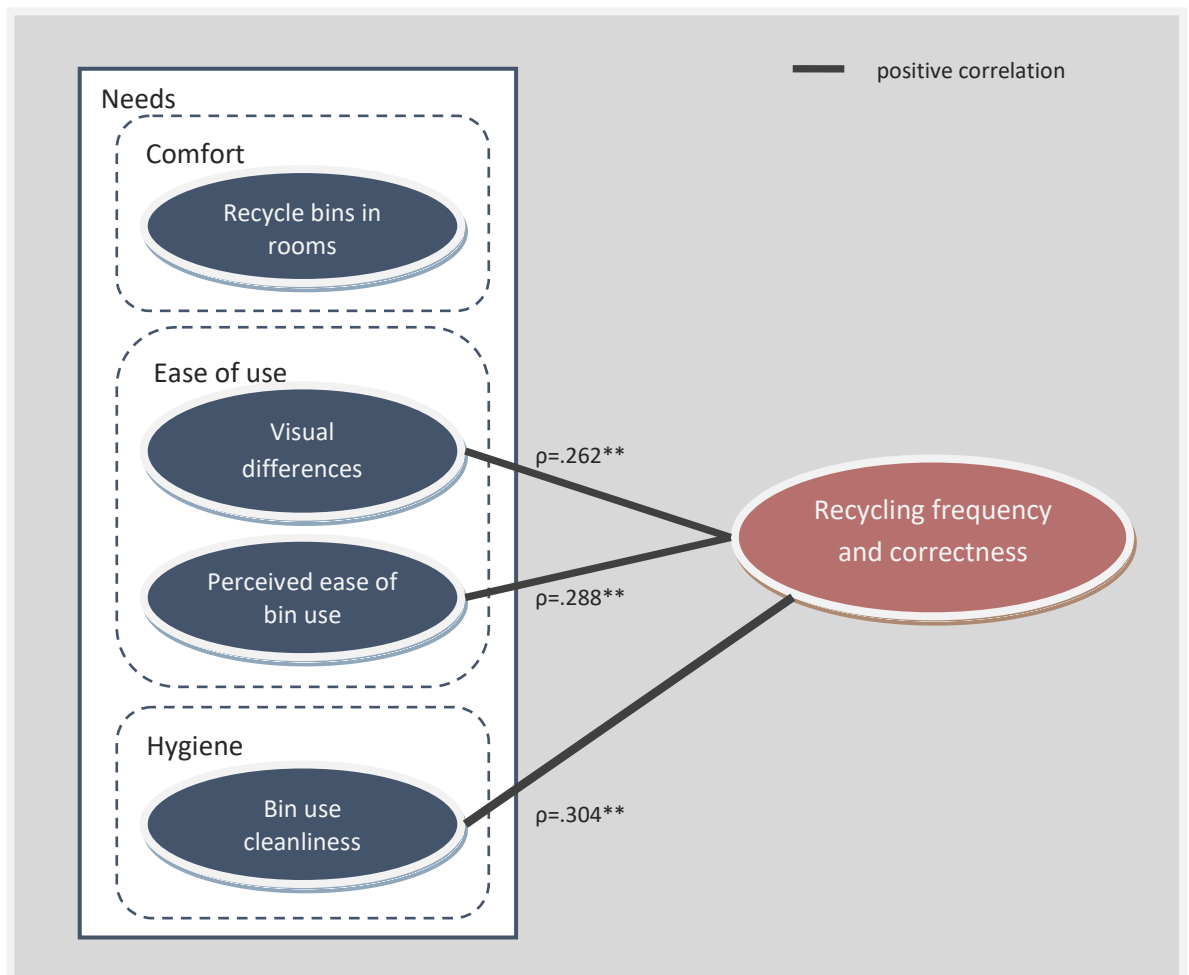


Figure 51. Correlations for Ease of use and Hygiene, and Recycling behaviours. * $p < 0.05$; ** $p < 0.01$.

Going forward, the analysis shows significant correlations between recycling practices in the kitchens and ease of use measures. The more visually different the waste bins are, the better the

reported recycling practices ($\rho=.262$, $p=.000$). Increases in perceived ease of bin use is also associated with better waste management behaviours ($\rho=.288$, $p=.000$). Finally, the cleaner the handling of waste bins, the better the frequency and correctness of recycling ($\rho=.304$, $p=.000$). When asked for reasoning their waste management behaviours, 43.7% of respondents reported to recycle because it was easy while 16.7% reported not to recycle because the bins were messy.

The visual differences the most correlated with recycling behaviours are:

- Size of bins ($\rho=.248$, $p=.000$)
- Shape of bins ($\rho=.221$, $p=.001$)
- Colour of the bins ($\rho=.215$, $p=.002$)
- Colour of the installed bag ($\rho=.197$, $p=.004$)

while some visual features did not show significant correlations with recycling behaviour:

- Visual instructions ($\rho=.113$, $p=.101$)
- Size and shape of the openings ($\rho=.106$, $p=.124$)

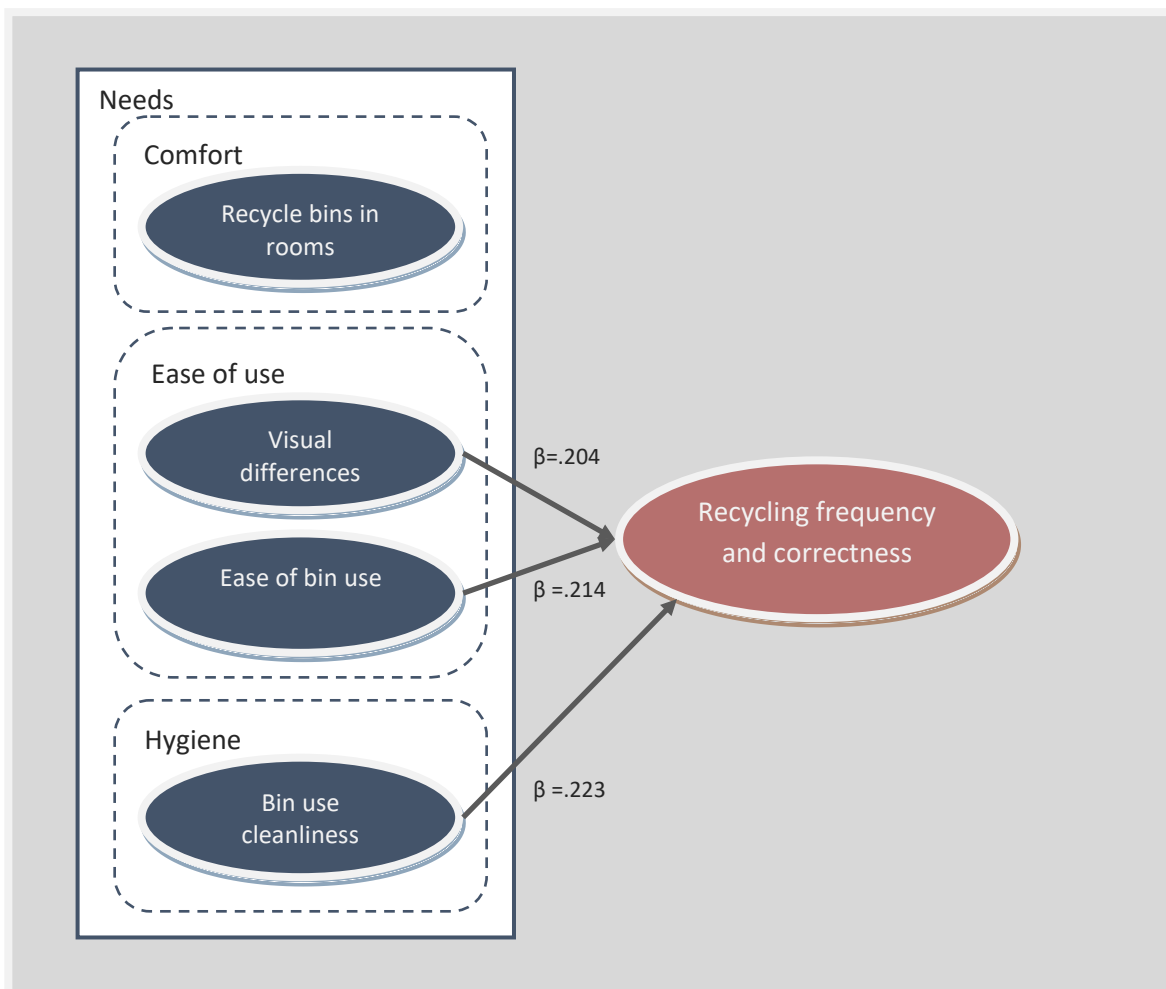


Figure 52. Multiple linear regression for predicting recycling. β -standardized coefficients.

In order to assess how the discussed factors together predict recycling behaviour in the kitchen a multiple linear regression was calculated based on visual differences, ease of use of bins and hygiene. A significant regression was found ($F(3, 206) = 16.295, p < .000$), with $R^2 = .192$, explaining 19.2% of variance in recycling frequency and correctness. Recycling improves by 3.4% for each additional visual difference, where the minimum number of visual differences was 0 and the maximum was 5; and decreases by 7% for each drop in perceived ease of use, where the latter is measured on a 5 point Likert-scale (0-Very easy, 4 – Very complicated); and drops with a further 6.7% for each decrease in perceived cleanliness, where cleanliness of bin use is measured on a 5 point Likert-scale (0-Very clean, 4-Very dirty) (see Table 25. Multiple linear regression - Recycling behaviour.).

Table 25. Multiple linear regression - Recycling behaviour.

Recycling behaviour - Multiple linear regression				
Variable	B	SEB	β	p
Constant	.688	0.508		.000
Visual differences	.034	0.011	.204	.002
Ease of use	-.070	0.021	-.214	.001
Dirtiness of bins	-.067	.020	-.223	.001

$R = .438, R^2 = .192, p < .000, N = 210.$

B - unstandardized coefficient for the linear regression equation; SEB - Standard Error of B; β - The standardized regression coefficient; p - probability value.

When students take out the waste, the frequency of their separation behaviour is significantly correlated with how many visual differences the outside waste bins incorporate $\rho = .265, p = .000, N = 180$. The differences that were the most correlated with waste separation frequency were:

- visual instructions ($\rho = .252, p = .001$)
- grouping of the bins ($\rho = .190, p = .011$)
- the colour of the bins ($\rho = .144, p = .054$)

while some visual features did not show any correlation with separating frequency:

- size of the bins ($\rho = .009, p = .903$)
- shape of the bins ($\rho = -.014, p = .856$)
- size and shape of the openings ($\rho = .002, p = .982$)

Respondents who reported to separate Often or Always ($N = 141$) stated their behaviour was facilitated by the below design features:

Table 26. Design Features aiding waste separation.

Design feature aiding waste separation	No. of Responses	% of those who Often or Always recycle
Visual instructions	106	75.2%
Bin colour	56	39.7%
Grouping of the bins	18	12.8%
Bin size	9	6.4%
Openings' size and shape	2	1.4%

Note: Multiple selections were allowed

5.3.4.2. Discussion and conclusion

The present study advocates that recycling and waste management in sustainable accommodations is a multi-stage process where occupant behaviours may be swayed by the design of the waste management facilities into more or less sustainable directions.

In the rooms, the availability of a recycle bin might be sufficient to prompt more frequent recycling according to the survey analysis, while the interviews offered explanation to the phenomena suggesting residents find it uncomfortable having to leave their room to recycle paper waste generated on spot.

In the kitchen areas, a significant part of variation in recycling is predicted by visual cues incorporated in the recycling facilities, by perceived ease of use and by perceived cleanliness. While it has been long established that cues in the design can guide appropriate use (Norman 2013), such as recycling (Duffy and Verges, 2009), the present study specifies that the size, shape and colour of the bins and the colour of the installed bag are associated with better recycling practices, while visual instructions and the size and shape of the bin openings were not found to correlate with recycling behaviours in the kitchen. Visual instructions were mentioned in the interviews as being supportive of recycling, however the statistical analysis of behaviours in the kitchen area did not support this relationship. Furthermore, recycling in kitchen is significantly correlated with perceived ease of bin use. Finally, recycling in kitchens is significantly associated with cleanliness of using the bins. Cleanliness of bin use is a rarely discussed factor in the literature despite its capacity to deter strong recycling intentions as seen from the occupant interviews. Earlier empirical studies of caddy use and food waste management practices also support the importance of bin cleanliness (Metcalf et al., 2012). The present study argues that perceived cleanliness of bin use is pivotal for recycling behaviours overall and not only for environmentally friendly food waste management practices.

The disposal of the waste and waste bags is the final stage of waste management and recycling process over which residents still have agency. In this stage, waste separation is still essential for appropriate recycling. The study suggests that the design of waste management facilities may support separation behaviour by appropriate use of visual cues such as visual instructions, bin colours and spatial arrangements, that is grouping of the bins.

In conclusion, recycling and waste management is a multi-stage process unfolding in several spaces and areas of sustainable accommodations. However, the pro-environmental behaviour of residents in each of the recycling stages may be facilitated by a separate and specific set of design features supportive of student needs. Overall, the design of recycling and waste management facilities can promote pro-environmental behaviour in sustainable student accommodations when it fulfils residents' comfort, ease of use and hygiene needs.

5.3.5.Overall Conclusion

The results of the questionnaire study bring statistical support for the inferences of the occupant interviews regarding the relationship between the extent of design support for residents' needs and environmentally relevant behaviours. The statistical analysis revealed that the support of residents' needs is significantly correlated with their environmentally supportive behaviour. The higher the support the more prevalent the environmental behaviour. Conversely, the lower the support the less pronounced the environmentally supportive conduct.

6. Architect Interview Study

6.1. Introduction

The overall aim of the Architect Interview Study is to develop understanding on ways sustainable occupant behaviours may appear on architectural agendas in the context of sustainable accommodation design, and thus answer the second research question of this thesis:

How do architects of sustainable student accommodations intend to support sustainable occupant behaviours and building interactions by their designs?

This study is driven significantly by the looming literature gap on how sustainable architecture may shape sustainable occupant behaviours and building interactions as presented in the Literature review chapter of this thesis. It was found that an increasing number of sustainable building performance studies argue that since sustainable buildings often underperform, these do not necessarily promote sustainable occupant behaviours. Furthermore, the same studies allude that a significant reason behind the lack of sustainable behaviour support of sustainable buildings is the gap between the projected or designed-for behaviour, and actual occupant behaviour, more specifically the architect's misconception on how occupants would use the building, eventually leading to unintended and unsustainable use. While this claim may well be valid, the very same studies only focus on occupant perceptions while the architect intentions are missing from their accounts. Indeed, the occupant perspective is indispensable to understand the reasons behind environmentally relevant occupant behaviours, however the present thesis argues that architect perspectives are crucial if the reduction of the architect-occupant gap is the goal. Furthermore, the present thesis argues that without understanding architect intentions, the designed and actual behaviour gap claim is questionable if not unreasonable and invalid. Hence, the main rationale behind the present study is to reduce the knowledge gap and to explore first hand, architect intentions on supporting sustainable occupant behaviours when designing sustainable accommodations.

The necessity of understanding architectural intentions to support sustainable occupant behaviour is further underlined by the overall theoretical framework informing this thesis. As such, the Theory of Affordances in its design disciplines-adopted form - Perceived Affordances - suggest that when architects' intentions match occupants' perceptions, or when the "designer conceptual model" overlap with the "user conceptual model" on the "system image", sustainable buildings are likely to be used as intended. Hence, understanding and developing knowledge on architects' "conceptual model" - investigated in this study via their design intentions – is a crucial

step in understanding how sustainable accommodation design may support sustainable occupant behaviour.

Finally, this study relies heavily on the theoretical understanding developed from the Occupant investigations performed and included in this thesis in chapters “4.Occupant Interview Study” and “5.Occupant Survey Study”. In the mentioned empirical studies, it was revealed that sustainability of occupant behaviour is related to how occupants perceive the design of the sustainable accommodation caters for their needs, also captured in the newly developed Feature-Need-behaviour table. Therefore, the present study investigates its research question by primarily looking at how architects employ design solutions with the intention to support occupant needs or sustainable occupant behaviours.

This chapter continues with a Methodological section, describing the sampling procedure, the data gathering protocol and the data analysis. The ensuing Results section presents the major findings of the study. Finally, the Conclusion section shows how the present study answers its research question and how it contributes to the overall research of this Thesis.

6.2. Methodology

The present study uses Thematic Analysis to analyse the data generated via interviews performed with architects of sustainable accommodations.

6.2.1.Sampling and Participants

The key criterion for participating in the study was to be an architect involved in the design of any of the four sustainable student residences where occupant data had previously been collected. Potential participants were contacted directly by email, however, the number of electronic invitations was limited to two. The invitation emails described the topic and the purpose of the study, clarifying that it aimed to understand architects’ overall approach to designing sustainable accommodations, how architects intend to support sustainable occupant behaviours by design and how they collaborate with other stakeholders to get their ideas through. In cases when the invitation had been accepted, the researcher provided further details on the study in form of the information sheets. Out of the four-architecture studios invited for participating in the study, three responded favourably to the invitation while the fourth studio was not willing to participate. The participating architects were the designers of Mountain Halls (MH), Daniel Defoe Hall (DDH), and Crome Court (CC) respectively. The architect from DDH and CC were both the project directors while the MH architect was a collaborating architect with BREEAM assessor qualifications. All three participants included in the study had delivered multiple student

accommodations projects, both with and without sustainability certificates, ensuring a broad experience and accumulated knowledge on the topic.

Finally, in order to ensure the anonymity of all participants, their names were replaced with pseudonyms that are used together with the abbreviation of the site designed by the participant, before each quotation. Example: *(Kris@DDH) "..."*

6.2.2. Data gathering protocol

Face-to-face, in-depth, semi-structured interviews were used to collect rich data on architects' design intentions and considerations. The interviews were guided by a schedule ensuring all important topics were explored with each of the participants. The main topics of the interview schedule were the following:

- Overall design approach to sustainable student accommodations
- Knowledge of student-occupants
- Design features supporting sustainability
- Considerations of indoor environmental quality and associated control systems
- Considerations of occupant-building interactions in the design

While the schedules were similar between the interviews, these also included site-specific questions developed based on the findings of the Occupant Interview Study and based on specific building characteristics learned during the site visits before or during the architect interviews. The tailored interview schedules with more site-specific questions were meant to make the interviews more relevant for the architects and help the better flow of ideas.

In order to synchronize with architects' way of progressing through projects, the interview questions were composed with consideration to the "RIBA Plan of Work 2013" (Halliday & Atkins, 2016) which is one of the most well-established and widely used conceptual models for the building design and construction process in the UK. This means that the schedule started with questions on decisions related to brief and conceptual design, progressed through questions on decision related to final design, to conclude with questions on decisions concerning the handover and potential post occupancy evaluations. This approach to think and discuss the project in the time sequence of its execution was meant to help architects to conjure up memories, potentially revealing their design intentions throughout the whole design process.

The interviews were performed in October, November and December 2016. Each interview lasted for about one hour. Two architects were interviewed in their offices and the third architect was

interviewed in the studied accommodation they had designed. Both types of environments afforded comfortable, relaxed and undisturbed discussions with the architects. The interviews were tape recorded with the written consent of participants and transcribed word-by-word.

Besides the interview discussions, the participating architects had been asked before the interview to bring relevant project documentations with them to the interview. The relevant project documentations could have been floor plans and 3D renders, elements of the planning permission documentations, building handover documentations or any other material found to be relevant and supportive of the interview discussions. The complementary data was expected to aid the interview process by helping architects to better remember the project and to articulate important decisions taken on the project. It also helped the researcher in better understanding the discussed buildings and its properties and the related design decisions. All participants responded positively to this invitation and brought various types of complementary data to the interview. Although these data, mainly project documentations, proved to be a great aid during the interviews, the participating architects could not hand over the materials due to reasons pertinent to confidentiality. Nevertheless, the researcher took notes on important aspects of the presented material and used it as complementary elements of the data analysis.

Besides the architectural project documentations, the interview data was also complemented with building observations from site visits and walkthroughs. The researcher was offered a walkthrough in the company of the architect in CC out of courtesy of the accommodation provider and of the architect. In DDH the accommodation provider also offered a walkthrough of the accommodations. In MH the accommodations were visited personally by the researcher and external observations were performed. The visits allowed the researcher to garner first hand impressions and experiences on the studied buildings and to visually document each site through photographs. These materials have also been used in the overall data analysis as supporting components of the interview transcripts.

6.2.3. Data analysis

Theory-driven and data-driven coding

The present study adopted the theoretical understanding developed from Occupant studies presented in the chapter “4. Occupant Interview Study” and “5. Occupant Survey” of this thesis, namely that there is a relationship between the design features of sustainable buildings, occupant perceptions of how far those design features support occupant needs and the sustainability of occupant behaviours.

More specifically, the present study aimed to reveal how architectural design intentions may fit with the aforementioned theoretical understanding of how design of sustainable accommodations may support and promote sustainable occupant behaviours. Hence it aimed to identify in the architect interviews potential cases and situations where architects explain the integration of a specific design feature and the purpose it may have served, with special interest to cases when the purpose may have been to support an occupant need or to enable or support sustainable occupant behaviours.

This approach implied that the coding framework, namely the Feature-Need-Behaviour framework, was predefined from the outset of the analysis, dictating a top-down, deductive, or theory-driven coding and analysis approach. While theory-driven coding was the main coding procedure, the researcher remained open for patterns in the data that might be related or might expand the theory-driven codes and thus might be relevant for better understanding the underlying mechanisms and the bigger context in which architects intend to design features, to support occupant needs and/or to support sustainable occupant behaviours and building interactions. Therefore, the analysis although guided, was not necessarily confined to the theory driven coding, but it also allowed inductive, data-driven coding.

Thematic Analysis was selected as a suitable data analysis method for the present study since it allows the simultaneous application and mixing of top-down and bottom-up approaches (Braun & Clarke, 2006; DeCuir-Gunby et al., 2011; Fereday & Muir-Cochrane, 2006). In the context of the present study, this means that it allowed the identifications of theory-driven codes clustered in Features, Needs, or Behaviours, while it also enabled the researcher to identify data-driven codes which might explain broader circumstances of the theory-driven codes. Since it suited the objective of the study well, this type of hybrid, “*codebook*” based Thematic Analysis, (Braun & Clarke, 2006; DeCuir-Gunby et al., 2011) has been selected and adopted as data analysis method for the present study.

The detailed explanation of how the selected method was applied is presented hereafter. Thus the following section shows how the “*codebook*” was compiled base on the chosen theoretical framework, and how the data-driven codes were developed from the raw data. Furthermore, the section describes how the codes were assessed, compared, paired, merged, separated or discarded to eventually elevate them to final, overarching themes that were thought to best capture the phenomena of architects intending to support sustainable occupant behaviours and needs via the design features of the sustainable accommodations.

Theory-driven coding for Features, Needs and Behaviours

Following the word by word transcription of architect interviews the researcher familiarized with the data by reading and re-reading the transcripts and taking notes on ideas that appeared to be relevant for the phenomena of interest. This was followed by coding the interviews, where within each interview, the researcher marked the design feature or multiple design features the architect discussed as Features and interpreted the architects' words on what those Features may have been purposed for to identify potential occurrences of occupant needs, labelled as Needs or sustainable behaviours, labelled Behaviours. Coding for design Features and intended Behaviours followed a slightly different process than coding for occupant Needs. Design features appear in architect recounts in an explicit manner therefore the identification of Features is straightforward and fits well with the chosen top-down approach. Behaviours intended to be supported by architects were also expressed fairly explicitly by architects and their coding was therefore relatively straightforward. On the other hand, occupant Needs intended to be supported by architects by the designed features were referred to sometimes explicitly, other times more implicitly. Thus, Need identification alternates between straightforward labelling and interpretation of architect recounts.

The following interview extract and the description of its coding procedure illustrates how the theory-driven coding was performed with mixing explicit coding with interpretative identification of the relevant text segments.

(Kris@DDH) "...just being able to use the spaces themselves, try to make say the stairs much more accessible, so to consider, ok it's a tall building but why not you know can get up to your rooms easy from, let's say, point A to point B and make them less reliant on, let's say use the lifts...you know it's a slightly nicer way then just say a cheap sort of throw away stair, so you know bring a bit of colour into it ..."

The Features mentioned by the architect in the above quotation are the "stairs" and was coded as "stairs". The accompanying Behaviour the architect mentioned to support by the stair design is "stair use" and this was coded as *stair use* and "make them less reliant on, let's say use the lifts" was coded as "elevator use". In terms of occupant Needs, the above extract provides both explicit and implicit fragments. For instance, architects explicitly mention the occupant Needs that the stair design intended to support when they say, "just being able to use the spaces", "try to make the stairs much more accessible", or "you can get up to your rooms easy from, let's say, point A to point B". These recounts were coded as "availability", "accessibility", and "ease of use". In contrast, the recounts "...it's a slightly nicer way ... bring a bit of colour into it ..." has been

interpreted as the architect intending to apply colour on the stairs to make stairs more appealing to occupants and was consequently coded as “*attractiveness*.”

To ensure the line of thinking behind the implicit coding is clear two more examples are provided hereafter. For instance, when architects mention to design “*decent-size kitchens*”, the word “decent” is interpreted as associating the size of the kitchen to a dimension which was believed to be comfortable for occupants, hence aiming to support the *Comfort* need of occupants. Similarly, where the architect explains the reason behind the use of pine trees by saying “*it will be lovely to live in a tower among the trees*”, the researcher interprets this as intention to support the occupant need for *Aesthetics* and *Attractiveness*.

This coding process explained above was performed on each architect interview transcript one-by-one, and eventually led to the development of individual tables with three columns, each column holding one of the predefined codes: Feature, Need, or Behaviour as visible in Table 44. Creating the Architect FNB table of the Appendix. However, architects did not mention in every case both the occupant Needs and Behaviours the designed features were meant to support. In instances where architects did not mention the intention to support sustainable behaviours by the specific design feature(s), the Behaviour cell was left blank (for instance see row 3 of “Table 44. Creating the Architect FNB table” from the Appendix). Similarly, where architect recounts did not refer to any occupant needs while discussing the purpose of a design feature, the cell in the Need column remained void.

The tables created this way capture individual occurrences of each architect discussing design features of sustainable accommodations and how those features may have been intended to support occupant needs or sustainable occupant behaviours. Additionally, in the final row of each table the Need and the Behaviour column counts how many design features architects mentioned and in how many cases there was an associated intention to support occupant needs or behaviours. This allows grasping how consistent architect intentions were with the chosen theoretical framework.

After compiling one independent FNB table for each interview transcript, the analysis proceeded towards merging the independent tables into an overall Architect FNB table (see Table 47. Architect FNB Table in the Appendix) to obtain an overall view of how the interviewed architects together considered support of occupant needs and behaviours via their designs.

Data-driven coding for the wider context of architectural intentions and decisions

Besides the identification of theory-driven codes describing Features, Needs and/or Behaviours, the researcher also identified situations or patterns in the data which were not directly related to the predefined codes of features, needs or behaviours but described the wider context of architect design intentions. This was believed to be important to better understand the circumstances under which the features were designed and how those circumstances might have shaped architect intentions to support occupant needs and sustainable occupant behaviours. To identify these situations, the analysis adopted the more explorative, bottom-up approach of Thematic Analysis and developed the codes from the data itself.

The data-driven coding process started with identifying segments in each interview transcript separately, that appeared to be relevant for understanding bigger forces driving architects' design intentions. It was assumed that a single comment in the data may be just as telling as reoccurring patterns in the same interview transcript, or comments which all architects shared. After coding the interviews, the preliminary codes were assessed, compared, grouped leading towards higher level codes. These higher-level codes were then further grouped and organized into nascent sub-themes and themes.

To better illustrate how the process of data-driven coding was applied in the present study, take for instance the following example from one architect interview. The data revealed that the respective architect provided cycle hubs in student residences to promote the more sustainable occupant practice of commuting which is cycling. The architect also mentioned that the design of the hub intended to be available, attractive, and easy to use. The cycle hub in this case was coded as the Feature, the practice of cycling was coded as the Behaviour while the "Availability", "Attractiveness", and "Ease of use" were coded as the Needs based on the theory driven coding process explained in the previous section "Table 44. Creating the Architect FNB table".

Nevertheless, the data-driven coding revealed that architects attended lectures and engaged in comprehensive studies on occupants' specific needs, behaviours, and lifestyles which in turn helped them in understanding how to effectively design for promoting cycling practices in university accommodations. This provided a broader understanding, the "story" behind how the occupant needs and behaviours have been supported by the design feature of cycle hub as visible from "Table 45. Data-driven coding 1." of the Appendix.

Furthermore, the same architect also revealed the hurdle of persuading certification bodies and planning departments to accept unique and innovative solutions for the design of the cycle hub, also captured in “Table 46. Data-driven coding 2.” of the Appendix.

Hence, the data-driven codes capture the circumstances through which the architect designed for occupant needs and behaviours via specific features. This provided a deeper, more comprehensive and more nuanced understanding of architect design intentions and decisions. By applying the same data-driven coding process for all architect interview transcripts and after assessing, comparing, merging or collapsing the codes, the following two themes emerged which were thought to best capture the larger context of architects’ intentions to support occupant needs and sustainable behaviour:

1. Knowledge on student accommodations and its occupants
2. Architect agency

The tables “Table 45. Data-driven coding 1.” and “Table 46. Data-driven coding 2.” from the Appendix exemplify codes and the themes the codes contributed to.

Mixing data-driven codes with theory-driven codes

Although the themes consisting of data-driven codes capture architects’ intentions from a broader perspective, they can almost always be linked to a specific feature-need-behaviour occurrence identified using the theory-driven codes. This is because architects, while explaining the wider “forces” or the context shaping and driving their intentions, also discuss specific design features that may have been affected by those forces. Therefore, the data-driven codes and themes were matched to the codes indicated by the theory when discussing the specific F-N-B occurrence.

Finally, ten main themes have been identified, concentrating around a specific occupant behaviour intended to be supported by the architects.

The themes and the story of each main theme is presented in the consecutive Result section of this chapter.

6.3. Results

This section presents the results of the architect interview analysis, developed with the mixed use of top-down and bottom-up approaches of Thematic Analysis. The top-down analysis results show how architects consider supporting environmentally relevant occupant behaviours and occupant needs via architectural elements and design features of sustainable student accommodations. On the other hand, the bottom-up analysis results present what is the larger context in which architects develop and implement their intentions to support occupant needs and sustainable occupant behaviours. While the analysis used both inductive and deductive approaches, the principal approach was deductive by pre-defining the coding framework of Feature-Need-Behaviours (FNB) at the outset of the analysis. The larger context of the FNB intentions revealed by the bottom-up approach was secondary in this analysis. This hierarchy is followed through by the reporting of the results as well. While architect intentions to support sustainable occupant behaviours and occupant needs will constitute the main story, the larger context of those intentions will be infused into the main story of the results.

Additionally, the results reveal that architect considerations and intentions can be captured into an Architect FNB table comparable to the FNB table developed from occupant interviews in Chapter “4. Occupant Interview Study” and corroborated quantitatively by Chapter “5. Occupant survey Study”.

The section is structured around the major themes developed from the analysis using the predefined FNB coding framework. Each of the main themes capture in a separate section a specific sustainable occupant behaviour or behaviour group architects intend to support by design features. Each behaviour-focused sub-section is further structured around behaviour-related occupant needs architects mean to support. The design features deployed to support those needs and behaviours are then included in the story of each discussed occupant need and sustainable behaviour. Finally, the larger context in which architects’ intentions develop and evolve, as revealed by the bottom-up coding, is woven in the story of the respective sustainable behaviours.

The following architect-projected sustainable occupant behaviours are the major themes the present study is structured around:

1. *Increase awareness*
2. *Gardening*
3. *Sustainable commuting*
4. *Sustainable vertical transportation*
5. *Cooking and reducing waste*
6. *Reduced resource use*
7. *Natural light use and reduced littering*
8. *Sustainable light-systems use*
9. *Sustainable heating and ventilation*
10. *Sustainable waste management and recycling*

6.3.1. Increase awareness

While designing sustainable student residences, architects frequently resort to design features that act as symbols of sustainability. These features are meant to convey to occupants and visitors alike the high environmental commitment of the building. Although raising awareness is not a sustainable occupant behaviour in itself, it can be argued that raising awareness may eventually lead to more sustainable behaviours and hence it can be considered as being an intention to promote more sustainable behaviours and lifestyles.



Figure 53. Green wall. CC.

The architect recounts exemplify how recognisability and attractiveness of the employed design features is being considered during design and concludes that raising awareness of sustainability was the intended outcomes.

Recognisability

In an attempt to signal the exceptional environmental commitment of the building, Frank integrates extensive greenery in the design. More specifically, the accommodation displays a living green wall, green areas around the building, and adult pine trees specifically brought in for the sake of the project. See Figure 53. and Figure 54.



Figure 54. Tree and vegetation. CC.

(Frank@CC) " I just think that the fact that when you see the building, the green wall I think...it is a symbol I think...It is actually a symbol...and I think it gives that sense that this is a different building... it gives the clue that this is a different building..."

“Giving the sense” and “giving the clue” suggests the architect considers green areas as recognizable symbols of sustainability.

Similarly, to Frank, Kris the architect of DDH also operates with green areas as symbols of sustainability in order to raise occupant awareness on sustainability. Kris also reveals that the sustainability signalling visual elements were intended to provide a subtle message rather than a highly conspicuous statement.



Figure 55. Suspended bicycles. DDH.

(Kris@DDH) "... (in order to signal sustainability) in the courtyard we tried to introduce a bit of a green area ..." and "...So visually I couldn't say, let's say, that it screams at you: 'I'm a green building'."

Kris's design further integrates visual elements that convey the idea of sustainability, such as the bicycles suspended from the ceiling of a cantilevered areas, meant to appear as an instantly recognizable symbol of sustainable transportation (see Figure 55.).



Figure 56. Recessed windows. CC.

Kris@DDH) "... you have sort of quirky little elements, let's just say cycles, being introduced almost as a bit of a marker ..."

When discussing signals of sustainability incorporated in the building design, Frank mentions recessed windows (Figure 56.). Although, the way recessed windows are believed to suggest the building is sustainable was not explained, the recount reveals that showing a building is "different" may equivocate to signalling the building is sustainable.

(Frank@CC) "...the other thing, probably, actually these windows, when you walk around, you'll see that the windows are deliberately set back from the depth..." and "... other than that I don't think there is anything these visuals that says the building is different..."

Windows, more specifically, reduced sized windows together with the sustainable materials used on the façade of the building are also present in Kris's account as potential signals of sustainability (Figure 57.). However, the architect also acknowledges that these symbols are likely not recognized by occupants, hence not capable to raise occupant's awareness on the sustainability of the accommodation.



Figure 57. Modest-sized windows. DDH.

(Kris@DDH) "...in terms of visual impression, the building itself, you know, smaller windows... we use materials (on the façade) which all have A grade. But people don't recognize that ..."

Although Kris mentions the window size as a potential, although unrecognizable, sustainability supportive feature, later he also reveals that his intentions to design smaller windows were filtered by compliance with the client's budgetary requirements and by the layout configuration of student rooms.

(Kris@DDH) "...the windows in terms of, let's say, the treatment of the windows in this instance was very straightforward because it's an area with expenditure that most clients don't throw out a lot on, because windows, glass windows are very expensive, the bigger they are the more expensive the rooms are and therefore they do not get the returns as quickly as expected before... in student rooms themselves... you do have a budgetary restrictions..." and " ...I mean I would love, you know, for the student resis to have say all glaze windows, it looks great, but generally, it never worked considering the furniture layouts anyways, so yeah I mean we always have the same windows where we actually place the windows in relationship, let's say, to the furniture behind..."

Frank also mentions that exposing the cross-laminated timber walls (CLT) is intended as a signal of sustainability for potentially raising awareness of residents about the sustainable character of the building (see Figure 58.).



Figure 58. Exposed CLT. CC. YouTube image

(Frank@CC) "I'll just show you now the CLT material, the construction, on the ground floor when you walk around there is a central space which is used for meetings at the corner of the building ... when you walk in the inside there is a panel of CLT which is exposed so you can see the construction ... so we wanted to expose a little bit.....so you can see the construction...so you can see this is how it was constructed..."

However, he continues by projecting potential improvements to the exposed CLT, suggesting that more information would have been needed in order to make the exposed structure a recognizable feature of sustainability. This can also be interpreted as an acknowledgment that the designed feature in discussion may have not reached its objective to successfully raise occupant awareness on the sustainability of the building and sustainability in general.

(Frank@CC) " ... I think maybe it could have been interesting to maybe just somebody thought about these things ... maybe we should have some information actually built in the building, what it has achieved... you know... so it's there..."

Interestingly the architect also mentions that the design team follows the principles of participatory design and closely collaborates with parties that have deeper knowledge on future occupant needs, wants and ways of using the buildings.

(Frank@CC) "...when we started we worked at stakeholder group meetings, and with the deputy team of the students, and so she and her team were responsible for, you know, getting people in and make sure that everybody is housed properly, and so she was very close to the way this was designed looking at the bedroom for example and the kitchen and dining spaces, what went into those spaces, and the architectural arrangement including the colour schemes...and so we worked closely with her to just determine these

things...so that stakeholder involved with the deputy of the students ... was a very close relationship that we had, and very successful. "

However, the architect still emphasises that more information may have helped the design intention to materialize into a design feature that achieves the aim of conveying the exceptional sustainable commitment of the building. Thus, the design intention is seen as a factor that may be limited in how successfully it materializes, by the knowledge and information on future occupants that are available to the architect. This is not to say that earlier collaboration to increase knowledge on occupants is not considered successful, but instead the message of the architect is that continuous improvement of knowledge may refine design solutions to better reach their goals.

Attractiveness

In addition to considering vegetation as a symbol of sustainability for occupants as presented above, Frank operates with vegetation to make the accommodations more attractive and provide a positive aesthetic experience for residents.

(Frank@CC) "... these fabulous trees here and so we... there is a space in-between the trees and so this tower would come through and this will be a lovely thing to live here in the trees you know... "

Beside the above occupant-centric design intentions, Frank also aims to support ecological diversity of the area:

(Frank@CC) "... there were mature trees on this site...we had to demolish those to make way for this building and so what we've done is given back in terms of the planting, in terms of landscaping some mature trees added in to the scheme... ...it's a way of giving back and adding to the pine diversity of the site. "

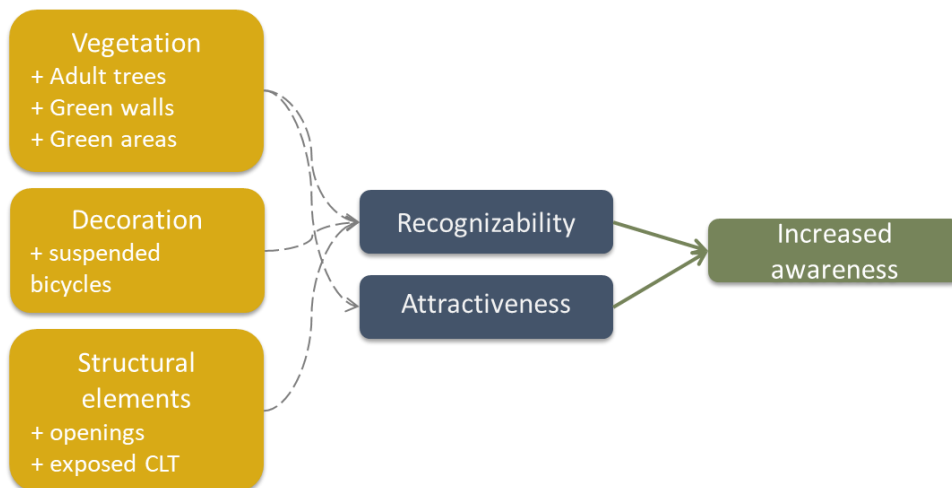


Figure 59. Increase awareness

Although Frank mentions to use the vegetation with the intention to raise awareness on the sustainability of the building, he does not allude to any pro-environmental behavioural response expected from occupants.

Hence, this subsection shows how architects of sustainable accommodations employ various design features to message the sustainability of the accommodations, some of which are employed with a joint intention to also support attractiveness of the sustainable building (Figure 59.) without necessarily directly linking these features to sustainable occupant behaviours.

6.3.2. Gardening

Availability

Green areas, beyond their use as symbols of sustainability, are also considered for the potential pro-environmental activities they can afford to occupants.

(Kris@DDH) "We are working on a scheme right now that suggests ... green growing areas for students ..."

Although the architect does not explicitly mention any occupant need, making the gardens available to occupants, thus availability can be considered as an occupant need the design caters for.



Figure 60. Gardening

Furthermore, Kris displays in-depth understanding of the behavioural dynamics of the student population interlinked with the short-term occupancy of the building type, and underlines challenges to maintaining occupant interest and engagement even where available spaces afford pro-environmental activities:

(Kris@DDH) "...always new people are staying there, that it's no guarantee that the present resident will take it on with the same interest as the previous years, say growing plants, something which would help sustainability..."

In the above recount, Kris highlights the unpredictability of occupant behaviours because of the constantly changing occupancy of the university accommodations. Although the architect has the intention to promote gardening by making the green areas available for occupants, the unpredictability of occupants' interests might just hinder the design to reach its intended aim. Therefore, in this case, the challenge to maintain interest due to the short occupancy dictated by

the building can be considered as a potential factor influencing the architect intention to promote gardening. Kris's considerations to promote gardening is captured in Figure 60.

6.3.3.Sustainable commuting

Availability, attractiveness, and ease of use

The section "6.3.1 Increase awareness" underlined how suspended bicycles (see Figure 55.) intend to gently raise occupant awareness on the sustainable character of the building. However, the architect who applied this design feature had more far-reaching aspirations in terms of promoting occupant behaviours than just raising awareness on the sustainable character of the building. These more ambitious aims are detailed by the following architect recount:

(Kris@DDH) "So visually I couldn't say, let's say, that it screams at you 'I'm a green building', but when look down on the ground, what we were actually trying to do and the encouragement this being a hub for cycling activities in Greenwich area..." and "...so visually when you walk in this particular building, outside, you know, a few little hints, you know, it's a place which encourage let's say cyclers...but when you get inside of it..."

The terms "screams" and "when you look down on the ground" is interpreted as rejection of using the building as a billboard of sustainability and instead embracing a more pragmatic approach to support sustainability and sustainable behaviour by accommodation design.

The cycle hub is perceived as an appropriate design solution to support sustainability and meant to enable and encourage residents and visitors alike to embrace cycling as a commute mode. The architect identifies a variety of amenities that are part of the design of the hub and may engage users to cycle:

(Kris@DDH) "...it does say that this is a development which encourages not only the students but outside people so they come in the cycle park, visitors, there is also a bike café in which we didn't involve in terms of development, but this is one where to say you have these new, broader retail elements which couples up with little coffee shops and cycle repair shops..."

Kris' recount suggests that the availability of the hub and its attractiveness - ensured by alluring amenities such as coffee shops and thematic retails spaces - are two key occupant needs that if supported by the design are expected to result in better resident engagement in cycling.

Although the availability and attractiveness were occupant needs considered to promote sustainable travel choice, the distant location of the residence from the main campus presented commuting as a primary occupant need the design was meant to cater for in compliance with

client requirements. Hence, another example on how clients' requirement and the very location of the campus might shape architects' intentions to support sustainable occupant behaviours.

(Kris@DDH) "...and so that was an important thing to them (the university) because at this particular hall of residence was quite remote from the rest of the campus, so there was an expectation that you know there will be other means of transportation, public transportation, or the ability that you can easily get from the hall of residence from here to the main campus itself."

Kris shows further consideration of less obvious occupant needs that might affect sustainable travel mode choices. He reveals that for the design of the cycle hub, the office resorted to accessing and interpreting research on student bicycle use behaviour patterns which helps the designer identify and respond to less obvious resident needs.

(Kris@DDH) "...and so we undertook a study with them (the university) ...rather than say simply provide endless racks of cycles on the assumption that students will come in, bring their own bikes or buy a bicycle and at the end of the academic year take their bikes with them ...you know that would be expected from students; but students rarely do that, students are not known to be going on and to buy the bikes and quite often let's say you have that spaces in the halls of residences full of cycle racks but maybe 20%, 30% says it is actually being used." and "...student don't go and buy their bikes, they don't often make the financial commitment on that, they don't want to risk..."

Instead of providing "endless racks" for bicycles, Kris designed a solution that complies with student needs and behaviours suggested by their study.

(Kris@DDH) "... (the client) accepted that students don't go and buy their bikes ...and so they end up using these free Brompton bikes which is put on by the university." and "... here what we ended up using was lockers where fold-away bikes can be easily put away ..."

Providing bikes and lockers for bikes is believed to make biking available for residents while the free nature of bikes makes bike use easy. These qualities are deemed to further enable and encourage residents in choosing biking as their travel mode.

This case illustrates how the architect interest in occupant lifestyles, willingness to invest time and energy in knowledge development on occupant lifestyles, and the developed knowledge altogether play their part in the final, less mainstream but more practical and potentially more successful design solution.

Kris further highlights that although a design decision may be well founded, it is challenging to persuade systemic actors such as planning departments and BREEAM assessors of its merits, especially if it deviates from mainstream solutions.

(Kris@DDH)“...we were able to reduce the number of cycle racks and it took quite a bit of persuasion to the planners as well as the BREEAM advisors, because the BREEAM does not accept to say, you know, this is sort of slightly different venture to let’s say a simple provision of cycle racks in terms of numbers to alternative means where, you know, you’re encouraging cyclers but not necessarily provide with the full facilities ...so the cycle racks...”

Kris’ recount suggests that supporting occupant needs in order to promote environmentally friendly behaviours can result in complex design solutions which might go beyond following BREEAM requirements. Nevertheless, approaching it with perseverance and pushing it through the planning process, just as Kris does, might worth the effort to eventually create solutions that support occupants needs while also promoting more sustainable occupant behaviours. Figure 61. summarizes the architect considerations to support sustainable travel modes by design via intended support for the needs of future occupants.



Figure 61. Sustainable commuting

6.3.4. Sustainable vertical transportation

Availability, accessibility, ease of use and attractiveness

Vertical transportation presents itself as a potential design opportunity to promote sustainable space use. Kris' recount reflects the intention to promote stair use and reduce reliance on elevators and associated electricity use by designing staircases that are available, accessible, attractive, and easy to use for occupants.

(Kris@DDH) "...just being able to use the spaces themselves, try to make say the stairs much more accessible, so to consider, ok it's a tall building but why not you know can get up to your rooms easy from, let's say, point A to point B and make them less reliant on, let's say use the lifts... you know it's a slightly nicer way then just say a cheap sort of throw away stair, so you know bring a bit of colour into it ..."

The aim to make stairs attractive to residents is inferred by wanting to "bring colour into it". "Just being able to use the space" and "more accessible" are explicitly mentioned and can be interpreted as intending to make the space available and accessible to occupants. Finally, ease of use is also explicitly mentioned as a design intention. Figure 62. plots the architect considerations to promote sustainable vertical transport modes in sustainable accommodations.

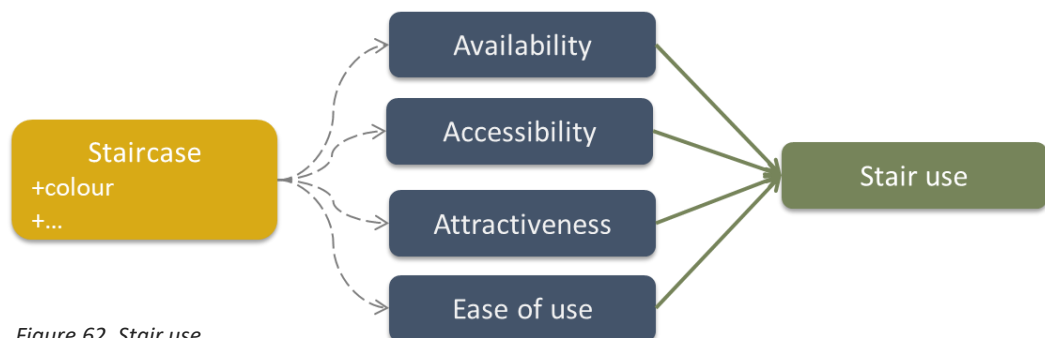


Figure 62. Stair use.

6.3.5. Cooking and reducing waste

Availability and comfort

The kitchen and dining areas of the halls are described by architects as potential vehicles of supporting more sustainable food preparation and waste management practices. Kris' narrative reveals that designing spacious kitchens are indented to enable residents to easily prepare their meals and consequently turn ordering food, with its inherent waste generation consequence, into a less attractive choice.



Figure 63. Spacious kitchens. DDH.

(Kris@DDH) "... decent size of the kitchens that serve the process ... so students could be encouraged to make, let's say, their own meals rather than, let's say, get boxed meals and what not, and before you know it, you have stacks and stacks of, you know, boxes which you actually throw away, it's not good from a sustainable point of view..."

Kris not only intends to make kitchens available to residents, but also aims to make them of "decent" size that "serve the process" suggesting he projects its comfortable use for occupants. His considerations are captured in Figure 64.



Figure 64. Cooking and reducing waste.

6.3.6.Reduced resource use

Information, feedback, competing and reinforcement

The concept of the information display is reported to be part of the architectural design and is intended as a potential tool to provide information and feedback to occupants on their resource consumption potentially prompting them to reduce their consumption. The panels are also considered by architects as an appropriate medium for organizing competitions between flats that may further stimulate occupants to reduce water and energy consumption.

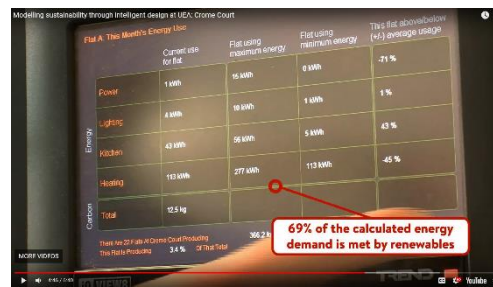


Figure 65. Information display. CC. YouTube image

(Frank@CC) "... in the kitchen and dining room there is a smart panel on the wall ... the idea was that we would have each of the kitchen and dining room spaces for 12 students and we call that a 'house'...so the houses would compete with each other at their energy use..." and "...the device was added towards the end but the original idea was part of the design ..." and see Figure 65.

In the case of Hannah, monitoring resource consumption combined with negative reinforcement is mentioned as an imaginable solution to reduce occupants' resource consumption. Although residents' potential dislike towards this strategy is acknowledged, the benefit - that it would make occupants pay attention to their consumption and hence to change their resource use behaviour - was perceived to outperform the shortcomings of occupant dislike towards the strategy.

(Hanna@MH) "... if students were monitored in the amount of water they use and they actually had to pay for it... they don't love it... or monitored for the amount of energy they

used.....yeah... but if people had to concentrate on what they are doing rather than just pfff... their behaviour would become quite different...".

Kris' recount contains both scenarios mentioned by Frank and Hannah. He comes through as being aware on how answering occupant needs for information and feedback on resource use, and waving that into competitions or negative reinforcement may generate student engagement in moderate resource use.

(Kris@DDH) "...they have things such as monitoring devices, meters at each of the clusters, so essentially let's just say that ...it's almost like a competition who is actually using the most energy and who's the most efficient in terms of going around and turning off the lights or not using so much energy ...so it's putting things in a subtle way in place to encourage, let's say, students to actually register what they are doing ..."

(Kris@DDH) "... they (another client) actually have meters within the rooms themselves and they sort of impose it on them (occupants), ...so they say ok you're allowed such and such if you go above a certain threshold than you will be, it will be added to you monthly... so you must go with the things like that... so that has, let's say, a clear definite sort of result..."

Hence, the interviews suggest that architects regard overall resource use as a set of behaviours that may be swayed into more sustainable patterns by the use of information displays. The displays are intended by architects to provide information and feedback to occupants in a manner that would prompt residents to reduce their resource use. Additionally, using the displays as components of more elaborated, accommodation run programmes that rely on occupants' competitiveness and reaction to reinforcement techniques is forecasted by architects to further contribute to sustainable use. Figure 66. captures how architects conceptualize and intent to promote moderate resource use by occupant-characteristic-aware information displays.



Figure 66. Moderating resource use.

It is important to highlight that although Kris suggests that the competitions and negative reinforcement techniques could further strengthen the effect of information and feedback provided by the panels in motivating occupants to reduce energy use, he constantly rejects the

more deterministic architectural approach of “changing behaviour” and feels very uncomfortable throughout the interview to use the word “behaviour”. In his view, students have a rebellious nature and imposing certain ways of doings on them, such as using the lights less, might be met with psychological reactance. However, instead of judging students for that, he reflects on his own youth and acknowledges that he would probably have exhibited similar reactions in case someone had imposed similar restrictions on him. Therefore, he advocates for a more sympathetic, subtle and gentle way of shaping the way occupants use the spaces by inviting, enabling, and encouraging those interactions rather than forcing those.

(Kris@DDH)“...So, let’s say, behaviour in terms of determinism, you know so you are of forcing people in one way or another, this got to be done in certain kind of subtle way, especially with students let’s say you, if you say you got to do that you have to turn off your lights and what not...I mean I was a student if somebody told me to constantly turn the light off I would be...you know I would have been angry just because of the rebellious nature...but if it’s done in a subtle way, you know you are not being forced, so it is one where students are actually being put in an environment where it is an enabler they don’t actually have to think about it, it’s in the back of your mind, you know, to say yes how well we’ve done in terms of let’s say retain our energy efficient manners within a group or that, you know, it’s better to actually come together to cook our foods together as group rather than individually going out or ordering a pizza which one might think it must be disastrous from an environmentally point of view. So, it’s subtle things like that, sort of getting students in the mindset as residents to be encouraged to do certain things you know you don’t have to be with the lights on.”

However, this less deterministic and more gentle approach to shape occupant resource use behaviours within the sustainable accommodations does not mean for Kris that the approach is less effective. In contrast, he thinks that given the life changing situation in which students are, moving away from the family home and moving into a new environment offers a great opportunity for the accommodations to help occupants in the uptake of new, less resource intensive building interactions.

(Kris@DDH) “...when students come in it’s often the first time actually they move away from their parents, you know,...and quite often you’re staying with let’s say, mom and dad and you leave your lights on in your bedroom, they don’t really think about, let’s say, the energy factors because for some reason you know, let’s say, it’s not a big priority to them... ahm but when you’re outside in, you know, how to adapt the mindset to think well, you know, do I actually need to use this energy source... so in this frequencies/occurrences what the university wants is to actively encourage, let’s say, the behaviour, so that they themselves (do it)... to have the heat turned off from maximum...etc... etc...they have things such as monitoring devices, meters at each of the clusters...”

The ideas presented above, besides giving more nuances to Kris' views and approach to support occupants to moderate their resource consumption in the accommodation, also highlights Kris' understanding and experience of students and student accommodation respectively. This knowledge and experience imbibe the architects' decisions and considerations when designing the sustainable accommodations and hence it also inevitably shapes the way he intends to enable, support and encourage sustainable occupant behaviours by the design of the accommodations.

6.3.7. Natural light use and reduced littering

The windows are highly prevalent design features in architect recounts. These are associated with the comfort and control need of occupants and with the environmentally sustainable occupant behaviour of natural light use and reduced artificial light use. Architects mention multiple facets of occupant comfort such as visual comfort, thermal comfort and good air quality to be considered during the design of windows. Occupant control is mainly discussed by architects in terms of glare control integrated in window design. The present section highlights the findings on how architects aim to support occupant needs and promote sustainable occupant behaviours by focusing on control and the various aspects of occupant comfort.

Visual comfort of views

At the design of the windows, one-way architects intend to support visual comfort is by providing views to residents. For instance, Kris states that special attention has been given to the views afforded by windows, despite the fact that the windows may be designed to be "smaller" to minimize heat gains.

(Kris@DDH) "...when you wake up you have let's say a decent view ..." and "...we don't have, let's say, huge glass windows which are slightly harder to deal with when it comes to heat gains in the rooms themselves ..."

Nevertheless, the exact design decision that is supposed to provide great views from student rooms is not detailed by the interviewee. On the other hand, Frank reports providing a view for residents by full-height windows in the student rooms and by furniture arrangements that allow views through the glazed surfaces of the dining area.

(Frank@CC) "...that was very much part of the process to make sure more light is coming into your room for a full height window as well as the view..." and "... the window, the lighting was considered of course and the dining/kitchen rooms, you know, the table you know this great view out across the campus ..."

Although supporting occupant comfort by ensuring views from the windows are among the expressed design intentions, no association with a desired pro-environmental occupant-building interaction emerged from the recounts whatsoever.

Visual comfort of daylight

Ensuring daylight for occupants is another design intention present in the narrative of architects and is commonly associated with the design of the windows. In order to provide naturally bright spaces, Frank designs full-height windows in the rooms and extensive glazed surfaces in the dining areas.



Figure 67. Room window. DDH.

(Frank@CC) "...that was very much part of the process to make sure more light is coming into your room for a full-height window... "and "...glazing in the dining places reduces the amount of (artificial) light you need and the window giving a great daylight into the spaces..."

Frank explicitly integrates into his account the reduced amount of artificial light use during the day enabled by good daylight levels, showing that pro-environmental occupant behaviour appears in architect recounts as an expected outcome of a windows related design decision.



Figure 68. Compromise to reduce littering. MH.

Kris, having to respect client business constraints, follows a standards-driven approach to ensure daylight levels are above a minimum threshold.

(Kris@DDH) "... all the rooms are actually given an assessment to make sure the light levels reach a minimum standard and the windows are sized accordingly ... because windows, glass windows are very expensive, the bigger they are the more expensive the rooms are and therefore they (developers) do not get the returns as quickly as expected ..."

Kris also states that lower reliance on artificial light in naturally bright spaces is "taken for granted", implying that the link between satisfying occupant needs for daylight visual comfort and subsequently reduced artificial light use behaviour are common knowledge in student accommodation design.

Hannah's window related design decisions also include occupant comfort, more specifically the visual comfort of brightness and the comfort of good air quality but are negotiated against the

client main requirement of preventing littering through the window. The latter is achieved by installing fixed louvers on the openable side of the room windows, which also leads to sacrificing daylight levels (see Figure 68.).

(Hannah@MH) "...we changed the windows to the louvers ...there was an issue around students throwing rubbish out of the windows, and they (the university) wanted a system that could naturally ventilate the room, maximize daylight but stop them throwing things out on the window... so we proposed louvered windows ... and the (daylight) figures came back not quite good because of these louvers ..."

Nevertheless, the detrimental effect of louvers on daylight is intended to be alleviated by the furniture arrangement that aims to maximize daylight at the desk by placing the table next to the window (see Figure 69.).

(Hannah@MH) "...that's why the desk is right by the window and everything else is at the far end, so you get... you are optimizing the daylight really ..."

In order to respond to the client's primary demand, Hannah chooses a solution that besides the potential to prevent littering is also perceived by the architect to ensure the safety and security of occupants.

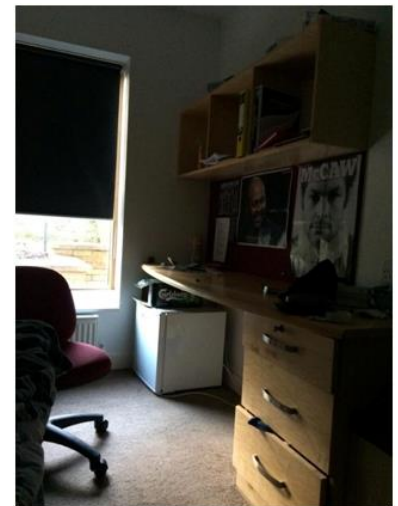


Figure 69. Maximizing daylight at the desk. MH.

(Hannah@HM) "...it'd gotten really-really well because of the security as well ... you know, no risk of falling..."

Overall, this case illustrates well how the support of one specific sustainable behaviour such as reducing littering and the support of occupant needs of safety might decrease the support of occupant daylight visual comfort.

Visual comfort of lack of glare and glare control

Preventing discomfort glare is a design intention associated to window design. Kris reports providing a dual system to occupants, which allows occupants to manipulate, or control the natural lights during the day without having to use blackout blinds.

(Kris@DDH) "...we often find to say a solution which enables, let's say, instead of having curtains that blank off light and glare coming from the outside...that they don't close the curtains and turn on the lights in the daytime, so what we do in most of the student residential accommodations, you have two systems, one where let's say in the evenings, and it's a BREEAM requirement anyway, you have the ability to close off and have complete blackout curtains, but you also have the other, controlling sun shading and

glare going into the rooms, so that you can manipulate the natural lights without having to put up the artificial lights, of course, in daytime."

In Kris's recount having a blackout only solution to combat discomfort glare, might lead to increased artificial light use during the day. On the other hand, providing occupants with adequate control over the natural lights might prevent discomfort glare while allowing natural lights in, and subsequently might reduce artificial light use. Hence, the applied design solution serves explicit intentions to provide control and protect comfort in order to reduce occupants' reliance on artificial lights and hence to promote more sustainable light use behaviours.

Hannah reports to follow BREEAM requirements and to provide blinds in order to prevent discomfort glare, without associating the design choice with environmentally relevant occupant-building interactions. Provision of blinds also implies the intention to support occupant need for control over glare.

(Hannah@MH) "Well, at the BREEAM they ask you to put blinds on every window, so that's what we did... there was no real detailed analysis in regards to which rooms would be more affected (by glare) over others... ahm... we've done projects where that has been done before, but not on this one, so we didn't do that, so we used just straight blinds."

Thermal comfort and good air quality

Apart from visual comfort, the window design of sustainable student accommodations also entails the consideration of occupant thermal comfort and the comfort of good air quality. Frank, for instance, reveals that full-height windows are intended to allow better air quality, while protection from the sun is accomplished by designing recessed windows. The latter design feature also serves aesthetic qualities by manipulating light and shadow (Figure 70.).

(Frank@CC) "... you've got the full-height windows as well, you know, just getting some more air into the room... so it was considered ..." and "... the windows are deliberately set back from the depth ...the reveal, we call that the reveal, this is set back... the reason for that is twofold: ... on these facades when the sun is coming down here this shades a bit the window; the window is on a face, a heat gain on window, but by recessing the window face you're shading that glazing and reducing heat gain; and it's also a really good architectural feature because it gives us shadow and light between the render and the depth of the window, so shadow and light so that's an architectural fact."

On the upper floors, providing shading is accomplished by designing a series of coloured glazed panels adjusted to the exterior of the



Figure 70. Full-height windows with shading panels. CC.

windows. Just as with the recessed window design on the lower levels, by adding coloured panels to the exterior of the upper level windows the architect balances the provision of shading with building aesthetics requirements.

(Frank@CC) "... we'd added this glazed film as a means to provide solar shading for these large windows at the top so that's the reason, but one reason for the use of those films is to shade the other was a technical thing dictated by the client, wanted some colours on the building, so this is our way to think about that ..."

Although, supporting occupant comfort through reduced solar heat gains, shading and air circulation were stated design intentions, no expected behavioural outcomes are present in Frank's accounts.

In Kris's narrative, catering for thermal comfort is manifested by proposing smaller windows, which is described as being more efficient in terms of controlling solar heat gains.



Figure 71. Windows size to limit solar gain. DDH.

(Kris@MH) "...smaller windows, we don't have, let's say, huge glass windows which are slightly harder to deal with when it comes to heat gains in the rooms themselves."

Similar to the previous case, regarding thermal comfort or good air quality no expected behavioural outcome is mentioned by the architect.

Although Kris brings the design of smaller windows as a solution to reduce heat gain and therefore to support thermal comfort, he also reckons that this choice was mainly predetermined by financial constraints dictated by the client, given that bigger windows are more expensive in which clients do not want to invest.

(Kris@DDH) "...the windows in terms of, let's say, the treatment of the windows in this instance was very straightforward because it's an area with expenditure that most clients don't throw out a lot on, because windows, glass windows are very expensive, the bigger they are the more expensive the rooms are and therefore they do not get the returns as quickly as expected before... in student rooms themselves... you do have a budgetary restrictions..."

Kris goes on and finds further support for his choice of smaller windows, such as the room layout, maintenance and safety and security, showing how the intention to design smaller windows which are also supportive of occupant thermal comfort was shaped by several factors outside of architects' intentions.

(Kris@DDH) "...I mean I would love, you know, for the student resis to have say all glaze windows, it looks great, but generally, it never worked considering the furniture layouts anyways, so yeah I mean we always have the same windows where we actually place the windows in relationship, let's say, to the furniture behind..."

(Kris@DDH) "...and also to say the overall maintenance restrictions, because in most of the student residences student should not or are not encouraged to actually open the windows all the way because unfortunately students being under pressure, have been known to throw themselves out of the window, and one thing which I suppose is a behaviour thing that students themselves cannot open it, so the window opening is very restrictive and they can't completely open it, universities and operators wish to protect their vested interest here... so that is an instance of windows and behaviour, is something that we do time and time again, I mean there is very little resis with balconies, very few student residences in the UK would have balconies, so you know that students would be able to go outside, which is a shame in many instances because you know an outward terrace is a nice thing to have."

In case of Hannah, allowing ventilation through the windows is an important aspect stipulated by the client, just as allowing sufficient daylight into the rooms. However, finding a solution that could impede littering through the windows has primacy for the client. The architect responds to plethora of requirements by adding fixed louvers on the openable part of the windows (Figure 72.).



Figure 72. Facade with fixed louvers. MH.

(Hannah@MH)"... there was an issue around students throwing rubbish out of the windows, and they (University) wanted a system that could naturally ventilate the room, maximize daylight but stop them throwing things out on the window... so, we proposed louvered windows ..."

While natural ventilation is indeed reported to be considered by the design of the louvered windows, projected air quality afforded by the solution is not mentioned during the interview. Finally, just in case of the other two architect presented above, environmentally relevant behavioural expectations, other than prevention of littering, are not mentioned to be incorporated into the final design provided by Hannah.

In conclusion, architects focus heavily on window design which is expected to fulfil occupants visual comfort need for view and natural lights, and is generally accepted to lead to higher natural light use and reduced artificial light use. The windows are also intended to protect occupants from glare discomfort while offering enjoyable views to occupants. Besides support for visual comfort of view, sufficient daylight and lack of glare discomfort, windows are further intended to comply with occupant comfort needs for fresh air by naturally ventilating the rooms, and thermal comfort by mitigating solar gains. Supporting these later occupant needs, in contrast with the support of daylight visual comfort or glare discomfort, are not envisaged by architects to enable or promote any sustainable behaviours. It must further be highlighted that beyond the above-mentioned intentions to support sustainable light use behaviour by window design, architects may also aim to prevent occupant littering behaviours via window design features. Additionally, the same design solution that prevents littering through the window is also found to be supportive of safety and security by preventing occupant from falling or jumping through the window. While this later solution may be considered as supportive of environmentally sustainable waste management, in order to achieve it, architects may knowingly compromise on occupant comfort need for natural light and air quality. Figure 73. captures the occupant needs architects intend to support via design of the windows and the environmentally sustainable occupant behaviours they plan to summon.

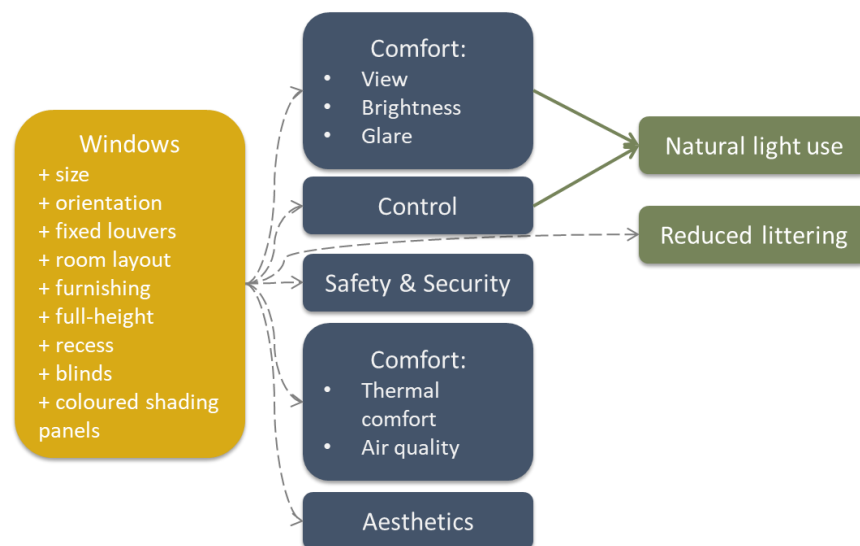


Figure 73. Supporting natural light use and reduced littering.

6.3.8. Sustainable light-systems use

Control and comfort

Architect interviews provide rich data on design approaches to artificial light systems incorporated in sustainable student accommodations and on how the implemented solutions are

expected to support occupant needs or to enable moderate energy use behaviours. The studied buildings incorporate low energy lighting systems controlled by manual or automatic controls, or a combination of both. While rooms are equipped with manual only light controls, bathroom pods, kitchens, dining areas and communal areas have only automatic or dual light controls.

The design choice of light controls is governed by the public-private divide of the spaces and by the specific activities the private and communal areas accommodate. While architects find manual controls to be more suitable and comfortable for private quarters, automatic controls are deemed more appropriate and comfortable for communal areas.

(Hannah@MH) "... so in common areas, there the automatic controls work well, ...so in terms of anything moving around if it's a communal space that's fine..., in personal areas they don't (work well), because everyone has this, they sit a little while on the desk and then they have to do this (gesticulates to activate PIR lighting) ...when they go off and you know you have to wait till the lights come back on and it's nothing worse ..."

By placing herself in the position of the occupants, Hannah projects the space-related activities and behaviours and makes intuitive assessments of how occupant comfort would be affected by the provided light control. She concludes that in private areas, occupants might have reduced movement that can cause the movement sensor-controlled lights to turn off on them and subsequently create discomfort, hence the provision of manual controls over automatic controls. On the other hand, the automatic light controls are considered suitable in the communal areas since occupants are in a constant movement, thus avoiding the discomfort of lights that might turn off unexpectedly. Therefore, the comfort of end-users appears to play a vital part in the design decisions concerning the light systems in sustainable student residences. Although Hannah projects occupant behaviours in the designed space, environmentally relevant occupant-building interactions are missing from her recount.

Apart from projecting occupant comfort and occupant behaviours performed in the spaces in discussion, Hannah considers the energy efficiency implications of light controls based on the BREEAM requirements.

(Hannah@MH)" ... that's very much set out in the BREEAM requirements... so in certain areas you should see set up certain types of control because it's the most energy efficient, so we end up with this situation we are going as energy efficiency and practicality ..."

Comfort also appears in Kris' recounts of light controls in the context of the bathroom pods. In his view, remaining in motion was the only way to maintain occupant comfort in spaces equipped

with automatic light controls. Conversely, when occupants engage in an activity that does not require constant movement, their comfort might be thwarted by the automatic light system.

(Kris@DDH) "(automatic lights are useful) as long as you remain fully in motion, cause that's the worst thing the lights turning OFF on you..."

Apart of acknowledging the potential discomfort sensor controlled light systems may cause, Kris also highlights the type of occupant comfort the light system design may support. By providing automatic control over the lights in the kitchens and dining areas, the residents are perceived to be freed up from the strain of having to remember to turn off the lights when the space is vacated.

(Kris@DDH) "... they do have PIR in the kitchen areas ... because quite often you know one walks in the kitchen to wash something and then on your way out the door closes behind you and you've forgotten to turn off the lights, you don't even notice it until you actually go back and use the kitchen again..."

On the other hand, Kris also emphasises that although the automatic control might promote sustainable light use patterns, not having control over the lights can equally lead to the discomfort of the space users.

(Kris@DDH) "This is where the automatic turning off, the motion activated switching devices has its downside...the (lack of) ability to control the lights."

Kris recounts further details how the lack of control over the brightness of the space can undermine occupant comfort.

(Kris@DDH) "... there is nothing worse than going to a little lounge area, and it's lit up extremely bright and students have absolutely no control over that, and then it becomes a sort of space where one, say, well you know, it's just doesn't feel cosy enough ..."

In contrast, providing occupants with granular control over the lights by switches and dimmers is perceived by the architect as a way of creating better "atmospheres", which can be interpreted as better supporting occupants comfort, with the additional benefit of saving electricity by reducing artificial light use.

(Kris@DDH) "... whereas to say having switches and uses of dimmers can create the right atmosphere for students to adopt those particular of spaces... and consider the same time the bonus of actually not using that much energy to the lights."

In the context of controls and diversity of the light systems, Kris also reveals how providing task lighting besides ambient lighting, could enable residents to use task lighting over the main lights and hence could facilitate more sustainable light use behaviours.

(Kris@DDH) "... a task type solution which say generally try to just minimize the light at the desk itself ..."

Furthermore, besides providing a higher degree of control and more options over the lights, Kris also emphasises the importance of providing aesthetically appealing lights. Nevertheless, the aesthetic quality the architect refers to remains unrealized in the design of the light system of the studied accommodation.

(Kris@DDH) "I think, let's say, something could be done a bit more imaginatively is the usage of stuff, of dimmers, a more interesting looking lights, rather than say the utilitarian type of lights that you often see..."

Despite Kris' detailed understanding on how to design light systems that support occupant needs and enable reduced energy use patterns, the actual solutions built into the accommodation are far more simplistic in consideration of occupant comfort. His reasoning for applying simplistic solutions suggests client requirements to be at the core.

(Kris@DDH) "I don't think enough effort had been actually spent with lights ... and it's usually, it's one of the first areas where clients try to make cost savings, and so all that we ended up doing unfortunately is that we did a check boxing type of exercise, we set the light levels at certain lux, give it to a lighting engineer, they say the light in the ceiling is sufficient, it's the cheapest easiest solution of all, therefore just put it in there."

Finally, in case of Frank, providing low energy lighting is the only communicated intention linked to the artificial light environment of the accommodation.

(Frank@CC) "...and of course you've got low energy light fitting as well..."

The specific resident needs the efficient lighting meant to support or the sustainable light use behaviour the designed solution could enable and encourage is not revealed by Frank.

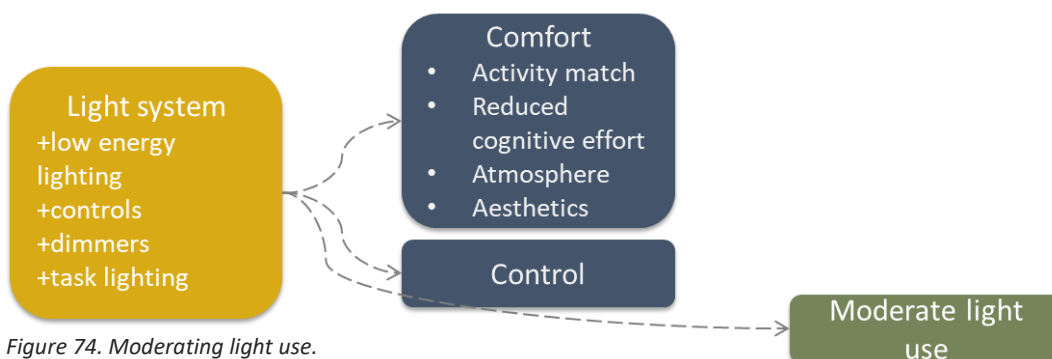


Figure 74. Moderating light use.

This section highlights architects' focus on light systems integrated in sustainable accommodations. Generally, they are driven to integrate low energy lights to comply with the sustainable character of the accommodation. While doing so they consider occupants from a

comfort and control needs perspective and intend to make the light controls comfortable to occupants. Occupant sensor lights are known by architects to increase comfort by reducing the cognitive effort of occupants for remembering to turn off lights when the space is vacated. However, architects also seem to be aware of the potential detrimental impact fully automated light systems may have on occupants. It has also been revealed that some architects have a deep understanding of occupant light use and how to design light systems that may be more comfortable but may also lead to lower artificial light use. However, this knowledge is not always put in practice due to project constraints imposed by clients, also highlighting the limits of architect agency. Finally, while architects consider how the light system impact occupant comfort and control needs and their artificial light use behaviours they do not reveal associating occupant needs directly with moderate light use behaviours. The light system design features, the known to be impacted occupant needs and the sustainable behavioural outcomes are captured by Figure 74.

6.3.9.Sustainable heating and ventilation

The heating and ventilation of the sustainable accommodations has a significant focus in architect's agenda where various design features are combined to respond to the needs of future occupants.

Thermal Comfort

Architects acknowledge the challenging nature of creating an ideal thermal environment that can match every occupants' expectation due to variation in individual occupant needs and potentially ensuing interactions with the building.

(Frank@CC) "Oh...it's always an issue in a building because we've always found...we just finished this building recently and you know you have this big office building with 2000 sqm so with a lot of people...so different people feel differently depending where they are in the building and you know some people want the window opened some people don't...so it's difficult...it's always difficult to find commonality..."

Nevertheless, despite its challenging nature, they do intend to ensure satisfactory temperatures in student rooms and thus to support thermal comfort, in various ways. For start, thermal comfort considerations appear on architects' agenda who may take a fabric-first approach and discuss the implications of using cross-laminated timber (CLT) as main structure of the building, including for walls, floors, staircases or even the roof. The architect seems informed about the thermal characteristics of the proposed material and its potential implication on the thermal environment of the accommodation being designed.

(Frank@CC) "...CLT it just gets hot in the hot weather, so it doesn't have that ability (like concrete) to absorb it (the heat) and cool it (the accommodation) ...it just retains the heat, more heat..."

Additionally, the architect's collaboration with the engineers to ensure the room will not overheat during the summer also suggests the significance of measures taken by architects to avoid the overheating of the structure and therefore prevent thermal discomfort.

(Frank@CC) "...so, we knew this when we designed it with the engineers and there was actually a projection that in really really hot weather, in the middle of the summer, the rooms will not overheat during the summer..."

The realisation that, despite the overheating character of the chosen timber structure the overheating of the rooms is minimized due to occupancy patterns specific to student accommodations also adds to the considerations of thermal comfort of future occupants.

(Frank@CC) "...and we said we do timber because during the hot summer months occupants will not be here...actually they will not feel the hot temperature..."

Besides considering the main construction material Frank also mentions considering the insulation, glazing to wall ratio, and the orientation of the building during the design of the accommodation.

(Frank@CC) "...we were looking at high insulation values, really good performing windows, insulation values on the roof...and the...ratio for glazing for solid wall construction, (and) the orientation of the building, it's a U-shaped building facing south so the very much, the vast majority of the rooms enjoy daylight sunlight I should say during the day..."

Supporting thermal comfort is also intended and manifested through the design of windows. Here the core or the issue is concerned with balancing the amount of natural lights a room receives against the solar heat gains which may overheat the room and cause thermal discomfort to occupants, as presented in more detail in section "6.3.7 Natural light use and reduced littering".

Control over the thermal environment and ease of use

Architects project occupant needs to control their thermal environment. Their response is to provision control systems which serve easy of use via their projected triviality.

(Hannah@MH) "...it's quite basic, they all have their own thermostats on their own little radiators or heaters don't they, they can set it themselves... so again it's very basic..."

However, based on data gathered on site visits observations, in certain cases, the operation of the accommodation seems to overwrite this intended design solution and substitute it with a solution that removes occupant control over the radiators by supplying rationed heating at given times of the day. Hence, the architects' intentions to provide occupants control over the thermal environment with easy to use controls may be hindered by the forces outside of architects' agency.

Beyond the brief mention of heating controls provided to occupants, architects do not recount of any specific sustainable heating practice they intend to promote in sustainable accommodations.

Comfort and control of indoor air quality

The interviews also reveal that architects are likely aware of some air quality challenges occupants of sustainable accommodations may be faced with. This prompts them to integrate design solutions that may improve on this aspect. In the citation below the architect does not specifically mention air quality comfort of occupant, however the concept of "bringing in fresh air" can be considered as an expression of to the intention to cater for good perceived air quality. Furthermore, his projection of occupant lifestyle highlights their consideration of occupants during design.

(Kris@DDH) "We also have a stream of fresh air being brought into the corridors so the air is not so stale, the air in the student accommodations it can get a bit musty... you know student with their indulgences from maybe the night before..."

In order to ensure good ventilation in occupant rooms and in the accommodation in general, architects integrate passive ventilation devices in the sustainable accommodations. To ensure the chosen solution does not diminish the aesthetic quality and attractiveness of the building façade, architects selecting trickle vents that can be sunk or applied onto window frames without having to create additional openings on the façade.

(Kris@DDH) "...in the design of it, is that we didn't want to see a building with appalling little holes in it there, which were say a little extract from each individual rooms, so we were careful with the detailing, so we just put a little slot in the window so you would never really know it's an extract, visually it wasn't too obtrusive at all so to compromise let's say the exterior of the building itself."

Finally, as presented in "6.3.7 Natural light use and reduced littering/Thermal comfort and good air quality" natural ventilation is also ensured by architects via the use of full height windows or via fixed louvers, the later serving the primary client aim to prevent occupants from littering.

In conclusion, the study finds that supporting the thermal comfort and the comfort of good perceived air quality is a fundamental aim in architects' consideration during the design of sustainable accommodations. Despite the challenges associated with supporting these occupant needs design professionals persevere and employ a plethora of design features ranging from orientation and building materials, to window design, shading devices or heating and ventilation control systems to name but a few. However, while discussing efforts to create accommodations with appropriate thermal environments doubled by good air quality, architects seldom recount of desirable sustainable occupant heating and ventilation patterns. Additionally, in certain cases the delivered designs may be adjusted to the need of the accommodation providers after the completion of the accommodations, marking the limits of architects' agency in adequately supporting core occupant needs. Figure 75. captures the discussed design features and the considered occupant needs.

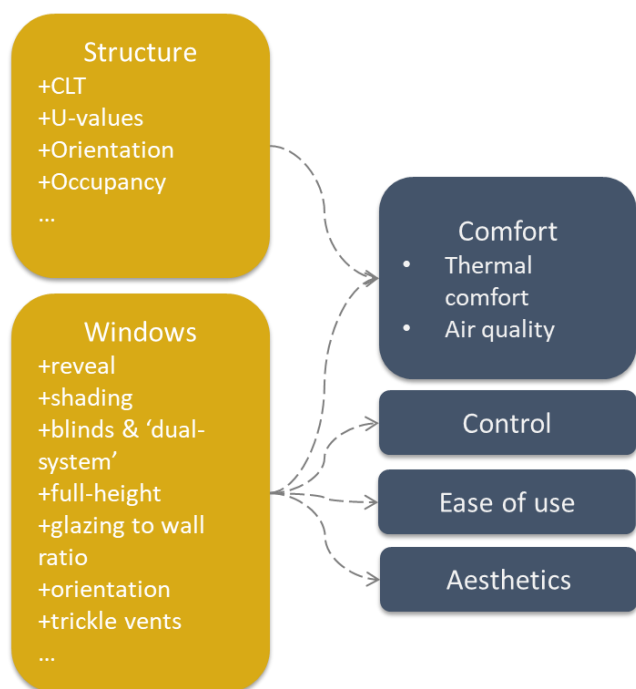


Figure 75. Sustainable heating and ventilation.

6.3.10. Sustainable waste management and recycling

Waste management facilities are design element that are revealed by interviews as not of high focus on the agenda of participating architects. For instance, the design of the waste receptacles falls entirely outside their view. They do report however marking the location of the bins inside the accommodations and making general provisions for waste management. In this activity they focus on complying with BREEAM requirements in terms of distances of bin locations.

(Frank@CC) "(Waste management is) ...well it's integrated...was part of the project and it's quite prominent in the space...the bins."

(Hannah@MH) “Yeah, ultimately we do, but again... is set out in the BREEAM assessment in regards to what you should provide... MH has exactly what the BREEAM says, what it requires you to have... ahm... so there are three different bins, I can’t remember, in each kitchen and a huge waste caddy and then the main bins have to be within so many meters of the front door...so hopefully the facilities are quite good in that respect.”

Occupant need considerations or behaviours are not discussed by either of the participating architect while discussing about waste management provisions, hence their intentions may be captured by the trivial box below.



Figure 76. Sustainable waste management and recycling.

6.4. Conclusion – extraction of Architect FNB table

The analysis of architects' interviews fills a significant gap in literature and answers its research question by revealing numerous ways architects intend to support sustainable occupant behaviours via the design of sustainable accommodations. The identified associations architects make between design features and support of occupant needs and sustainable behaviour is conveniently captured in the Architect FNB Map (see Figure 77.) which may also be regarded as the "conceptual model" (Norman, 2002) architects have about sustainable accommodations and the sustainable use of those accommodations. The findings overall propose that intending to support sustainable occupant behaviours and occupant needs may be common in sustainable accommodation design, highlighting a hitherto unexplored yet significant professional focus on the topic.

While the architect interviews show that it is a common architectural intention to support occupant needs or sustainable behaviours by design, simultaneously associating design features with occupant needs and with sustainable behaviours is not omnipresent. The themes presented in the Result section show that there are cases when design features are meant to support a plethora of occupant needs without any consideration to sustainable occupant behaviour, and there are also cases when design features are meant to support specific sustainable behaviours without any consideration to occupant needs. Interpreting this finding in the theoretical Feature-Need-Behaviour framework suggests that clarifying what are the missing Needs related to the intended Behaviours, and what are the sustainable Behaviours that may be facilitated by supported occupant Needs, may be a significant step towards improving behavioural sustainability of sustainable accommodation design. Hence the study identifies a likely significant improvement point in the architecture of sustainable accommodations, in line with the major aim of this Thesis.

Additionally, the analysis of the interviews reveals that when architects intend to support occupant needs and sustainable occupant behaviours, they often negotiate the final design solution against multiple and often competing intentions. They may negotiate the support of one occupant need while intentionally compromising on the support of another occupant need, as exemplified by the case of imposing PIR-only light controls which are meant to support occupant comfort while knowingly diminish control, where the decision is informed by the expected more sustainable behaviour pattern. While this is thought by architects to be conducive of sustainable use, in the context of FNB framework (which suggests all significant occupant needs should be supported by design in order for sustainable use to be more prevalent) it can be argued that

finding design solutions that do not sacrifice support of any specific needs may be a further path for improving sustainability of sustainable accommodations.

Furthermore, the results also expose that architects' design decisions may be also shaped by other forces than solely their intentions to support occupant needs and behaviours. While some of the forces may be inherent to the architect itself, others are outside their agency. The results show that architects' design decisions that support occupant needs and behaviours may be formed by their own approach to sustainability and sustainable accommodations, and their knowledge acquired on occupant behaviours and lifestyles, which can be considered inherent to the architect. On the other hand, the results also expose that architects' decisions may be swayed - and their need supportive intentions constrained - by external forces, outside of architects' immediate agency. Such forces may be the client requirements, planning departments, BREEAM assessments or safety and security requirements and regulations.

All in all, the study shows that although the FNB framework is not uncommon to architects and that architects via the design of sustainable accommodations have good intentions to support a variety of occupant needs and sustainable occupant behaviours, there is still considerable room for improvement to better support occupant needs and behaviours for which the present study offers ways of thinking. It is also an important to acknowledge based on the findings that the final design choices and intentions do not exist in vacuum but are shaped by forces internal and external to architects. Hence, the study suggests that architects' intentions to support sustainable occupant behaviours needs to be understood in the context of those forces and opportunities for improvement also need to be offered with that in mind, if effective solution for supporting sustainable occupant behaviour by design is the goal.

While the present chapter provides a good overview of how architects employ design features to support occupant needs and promote sustainable occupant behaviour, the question arises how architects' way of approaching the matter compare with the way occupants perceive design features support their needs and sustainable behaviours. This intriguing topic is explored in the "Comparative Analysis and Synthesis" chapter hereafter.

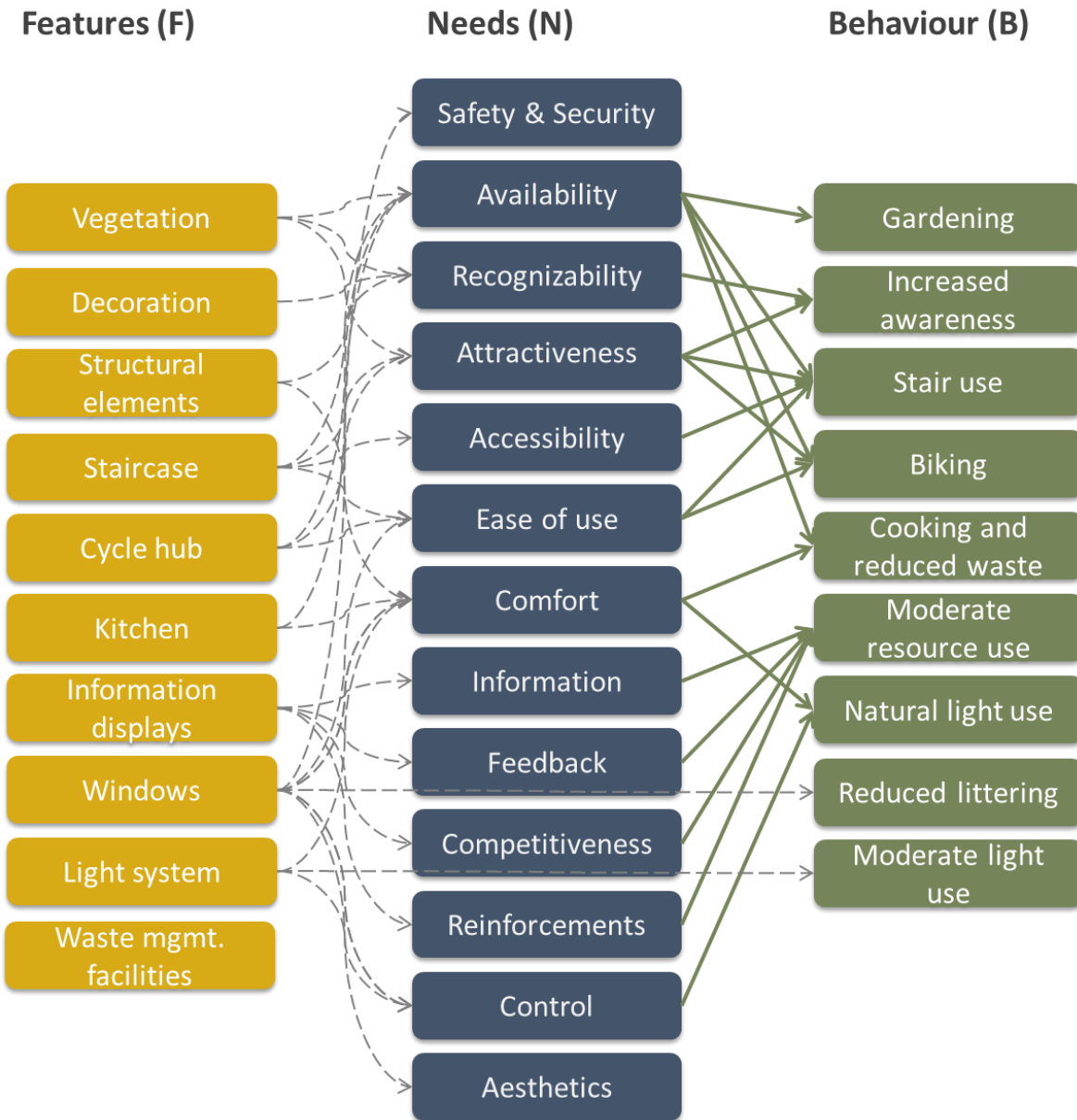


Figure 77. Architect FNB Map

7. Comparative Analysis and Synthesis

7.1. Introduction

The aim of the “Comparative Analysis and Synthesis” is to compare analytically occupants’ perceptions of how sustainable accommodations may support them in behaving sustainably, as captured by the Occupant Interview Study and the Occupant Survey Study, with architects’ intentions of supporting sustainable occupant behaviour, as identified from the Architect Interview Study, and thus answer the third research question of the thesis:

How do occupant perceptions compare with architect intentions and what are the good practices and the opportunities to better afford environmentally sustainable occupant behaviour by the design of sustainable student accommodations?

The first rationale for the synthesis is to reduce the literature gap and provide knowledge on how architects’ intentions fit with occupants’ perceptions by identifying matches and the mismatches between the two in the context of sustainable behaviour-affording sustainable accommodations. The second rationale for the present study is to identify architectural opportunities for improving the behavioural sustainability of sustainable accommodations.

The overall thesis recognises as its theoretical stance the design embraced concepts of Designed Affordance and Perceived Affordance which suggest that “good design” happens when the “designer mental model” overlaps with the “user mental model” on the same “system image” (Norman, 2002). Translating that into the context of the present study, “good design” becomes sustainable use-conducive design of sustainable student accommodations. Furthermore, it is suggested that sustainable behaviours may be more likely in the sustainable accommodations when architects’ intentions are synchronized with occupants’ perceptions on how the sustainable buildings afford sustainable behaviours, presupposing that the sustainable use is also the intended use. Hence, the present study focuses on the overlaps and gaps between occupant and architect perspectives regarding the sustainable behaviour affordance of sustainable accommodations, and brings evidence based on primary empirical data on how those overlaps and gaps may eventually sway the sustainability of occupant behaviours and building interactions.

The consecutive sections will present the Methodology of the Comparative analysis and synthesis, followed by the results of the comparative analysis organized around environmentally significant occupant behaviours. Finally, the section will end with concluding remarks.

7.2. Methodology

Given the present study aims to contrast occupants' perceptions with architects' intentions, both captured in the previously presented empirical studies in Chapter 4, 5 and Chapter 6 respectively, it adopts Comparative Analysis as its overarching methodology.

7.2.1. Data

The study builds on the qualitative and quantitative data collected for the aforementioned empirical studies of this Thesis. However, it relies mostly on the data from three out of the four sites. The rationale behind this is that while the Occupant Interview Study and the Occupant Survey Study, include occupants' perceptions from all the four sites, the Architect Interview Study was built on interviews with three of the site architects, the fourth site architect missed the opportunity to participate in the study. Therefore, where the comparative analysis is concerned with the overall occupant and the overall architect data, includes all four sites in case of occupants and three sites in case of architects. Nevertheless, the parts of the comparative analysis that compare specific perceptions of occupants of a specific site with architect intentions from the same accommodation, only make use of data from sites - MH, DDH and CC - where both occupant and architect data are available.

The initial data of the present study is provided by the Feature-Need-Behaviour tables developed from the Occupant Interview Study (Figure 34.) on one side and Architect Interview Study (Figure 77.) on the other. The Feature-Need-Behaviour tables are identified as a starting point, since these entities have identical structure and data organisation, allowing a comparison between the occupant and architect perspectives on how sustainable accommodations afford sustainable occupant behaviours, and permit an easy review of the relationships between design features, associated occupant needs and related sustainable occupant behaviours.

In addition to the FNB tables, the present study uses as dataset the results of the interview based empirical chapters included in this thesis (Chapter 4 and Chapter 6). The results of these empirical chapters provide an in-depth qualitative reflection on each element of the FNB tables, and its relationships with other elements, hence allowing a more nuanced understanding on the FNB associations from the perspective of occupants and from the perspective of architects.

Furthermore, the collected quantitative data and parts of the results of the Occupant Survey Study (Chapter 5) are also included in this chapter. On one side, the results of the Occupant Survey Study indicate where the relationships between specific Features, Needs and Behaviours are statistically significant, marking their importance for the present study. On the other side, the

quantitative data can be grouped by location, revealing the design of which location performs better or worse, also feeding parts of the comparative analysis. The use of the quantitative data is described in a following section.

Finally, the photographic images gathered during site visits and provided by occupants are also used and included in the write-up, with the intention to visualize discussed design elements.

7.2.2. Comparative analysis

7.2.2.1. *Selecting the behaviours of interest*

The present study continues from where the occupant and architect investigations left off, and compares occupant perceptions and architect intentions. It commences the comparison by first juxtaposing the Occupant FNB map (Figure 34.) with the Architect FNB map (Figure 77.). Since the thesis assumes the theoretical stance proposed by Perceived (and Designed) Affordances according to which intended, in this case sustainable behaviours, are more likely to occur when occupant perceptions are matched by architect intentions, the synthesis primarily focuses on how occupant perceptions in the Occupant FNB map are matched/or mismatched by architect intentions. Hence, the Occupant FNB map is considered the reference, the leading data to which Architect FNB map is compared. The overlaps are interpreted as suggesting potentially good practices, while the gaps as opportunities for improvement, this way contributing to the principal aim of the thesis.

In order to work with a strong data set, the present chapter focuses on those areas of the Occupant FNB table that were tested in the quantitative analysis presented in Chapter 5. These areas cover the environmentally significant occupant behaviours most frequently mentioned in the occupant interviews: light use in rooms and communal spaces of the flats, heating and ventilation, and waste management. Hence, the sections of the Occupant FNB table driving the Comparative Analysis and Synthesis are supported by strong, qualitative and quantitative data, further increasing the credibility and validity of the findings.

Additionally, a section is included to discuss the areas of the Architect FNB table unmentioned by occupants. While in this section, based on the available data, only guesses can be made on the reasons why architect intentions went unmentioned by occupants, it is important to discuss those gaps as they may represent mismatched affordances.

7.2.2.2. *The analysis process*

First, sections of the Occupant FNB tables pertinent to one specific environmentally relevant occupant behaviour and the associated occupant needs and design features are separated. The

corresponding sections of the Architect FNB tables are also subsequently highlighted. These subsections of the Occupant FNB tables and the Architect FNB tables are then compared with each other allowing the instant identification of elements that overlap or mismatch. For instance, the Occupant FNB map section pertinent to an occupant behaviour of interest may look as the one in Figure 78. while the section from the Architect FNB map may be similar to Figure 80. The two sections placed together instantly show a good overlap on “Need 1” and “Need 2”, and



Figure 80. Potential section of Architect FNB table.



Figure 78. Potential section of Occupant FNB table.

discrepancies on occupant “Need 4” which is missing from the architect FNB table section and on “Need 3” that is only present on Architect FNB but is also not linked to any expected sustainable behaviours.

Furthermore, it is well-visible that Architects employ design “Feature 2” to promote a sustainable “Behaviour A” while Occupant FNB tables are oblivious to “Feature 2”. Hence this step allows grasping from a higher level the similarities and differences between occupant perceptions of how sustainable buildings support sustainable behaviours and architectural practices to support the same sustainable behaviour.

The areas missing from the Architect FNB, in this case “Need 4”, are considered by the thesis as key opportunities for improving sustainable architecture to better support behavioural sustainability of sustainable accommodations, while the overlaps between the two table sections may represent good practices that might worth popularizing in sustainable architectural practices to better support sustainable behaviours by design.

Additionally, the Comparative Analysis and Synthesis looks at the overlapping components of the two tables sections, such as “Need 1” and “Need 2” from the previous example, with a more critical eye and analyses their overlaps qualitatively. This is done to assess how well the needs and behaviours expressed by occupants are indeed conceptualized and projected similarly by architects. In this step, the analysis revisits the results of the earlier empirical chapters of this thesis, which provide nuances to what perceived, and aimed-to-be-supported needs and behaviours are.

While investigating the gaps and overlaps of the FNB tables and the nuances of perceived and intended to be supported Needs, the quantitative data is also woven into the analysis and its use serves various purposes.

Firstly, it is used to assess how significant for the overall thesis, the gaps and overlaps between the occupant and architect FNB tables, may be. Cases where an occupant need in a statistically significant relationship with a sustainable occupant behaviour is found to be less-well or un-matched by architectural intentions, signal strong opportunities for improvement. Conversely, when the same Need is found to be intended to be supported by the architects, the researcher marked the support of the Need as a significant positive practice that may deserve recommendation in architectural practices concerned with sustainable accommodations.

Secondly, the quantitative data also enables extraction of descriptive statistical measures on the perceived support of occupant needs and/or sustainability of a related behaviour.

Thirdly, the quantitative data is used to assess how occupant perceptions or behaviours differ by location, showcasing the extent to which a specific element or feature integrated in a specific accommodation designed by a specific architect may be supportive of the needs or sustainable behaviours of occupants residing in the same accommodations. Where significant differences between locations are identified, the underlying design solutions are discussed as potentially good practices or as opportunities for improvements in the designs of future sustainable accommodations. This latter way of analysing the quantitative data is specific to the present chapter and not only reinterprets but also complements the quantitative results described in Chapter 5.

7.3. Results

7.3.1. Light use in the rooms

The present section discusses the results related to daytime artificial light use in the student rooms. It iterates one-by-one over the occupant expressed needs that may relate to sustainability of light use behaviours and converses on how occupant perceptions match architect intentions on the support of each occupant need.

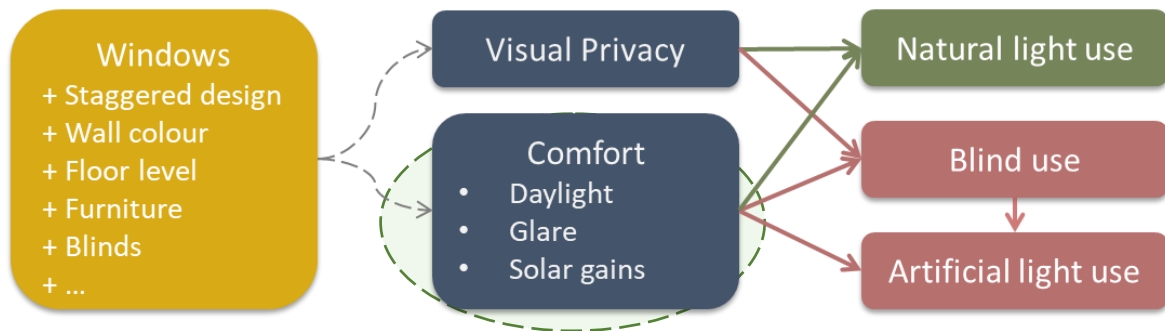


Figure 81. Occupant FNB - Light use in rooms

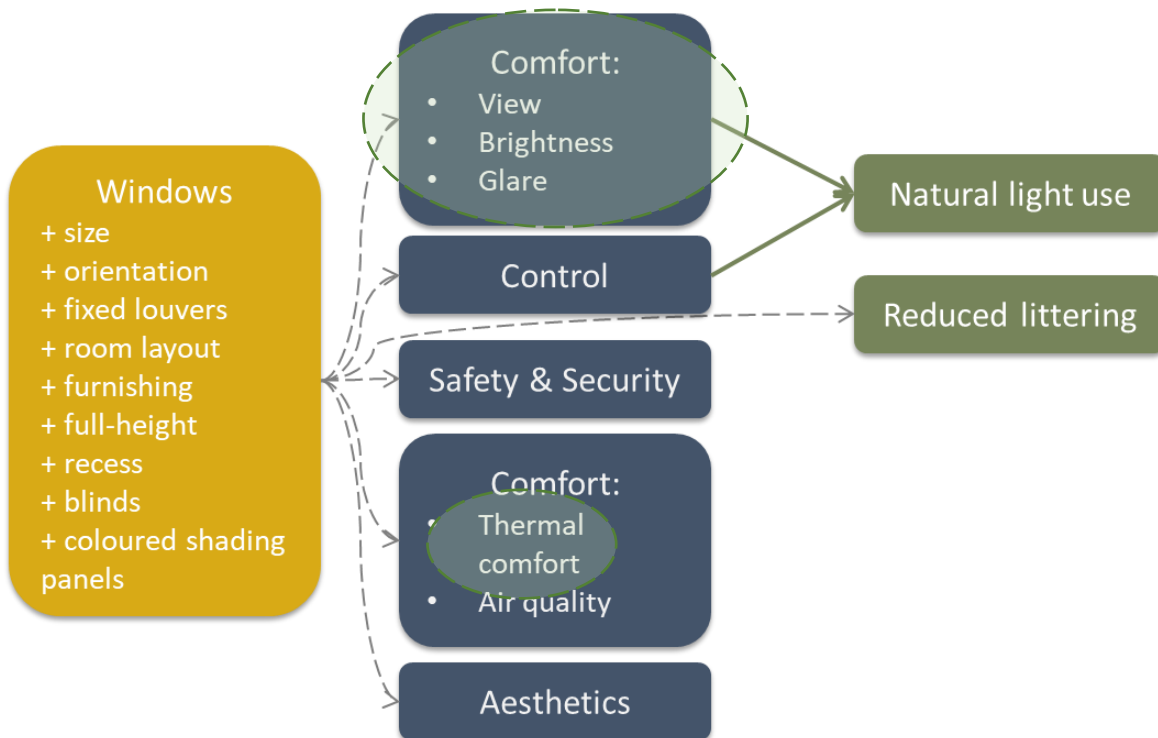


Figure 82. Architect FNB - Light use in rooms

7.3.1.1. Visual comfort of daylight

Juxtaposing the occupant perceptions based FNB map - Figure 81. - and the architect intentions based FNB map - Figure 82. - shows a good overlap between architectural intentions to support good daylight levels via window design and occupants' perceptions. This is important for sustainability of occupant behaviour since perceived visual comfort of daylight was found to significantly correlate with daytime artificial light use. The more residents perceive their rooms as naturally well-lit, the less artificial light use they report (Figure 38.). Promisingly, more than 75% of occupants perceive their rooms as naturally well lit (Table 27. Perceived brightness of the room.) suggesting that overall architectural intentions may fit well occupant perceptions setting the stage for sustainable light use patterns.

Table 27. Perceived brightness of the room.

		N	%	Cumulative %
Q3_5: On a typical day my room is bright.	Strongly agree	84	37.84%	37.84%
	Agree	69	31.08%	68.92%
	Neither agree nor disagree	17	7.66%	76.58%
	Disagree	39	17.57%	94.14%
	Strongly disagree	13	5.86%	100.00%
Total		222	100%	

However, the architectural intentions for supporting good daylight levels are not always well-translated into the final design. In one case, the natural brightness of the rooms, although considered at the design phase, is intentionally compromised by adding fixed louvers (see Figure 83.) to fulfil competing client requirements of preventing littering through the window (pg. 195). Nevertheless, the same architect reports investing effort in optimizing the louvers-generated poor daylight levels in student rooms by furniture arrangement. Placing the desk next to the window is thought to improve the light conditions in the rooms (pg. 195). However, the optimization seems to yield modest results given that occupants of the same



Figure 83. Louvers on MH room windows

accommodation report in the interviews having low light levels in their rooms and reliance on artificial light during the day (pg. 94, 98). This may explain why the accommodation has the highest percentage of occupants, 46% “Table 28. Daytime artificial light use reasoning”, who use artificial light due to insufficiently perceived daylight levels, and with 6.9 hours per day, has the

highest average artificial light use duration when compared to the other accommodations “Table 29. Daytime light use duration”.

Table 28. Daytime artificial light use reasoning

Q9: What would be the reasons for you to use the lights in your room during the day?	MH	DDH	PPQ	CC
Total respondents	69	46	81	26
It is a bit dark in my room during the day, even with the blinds/curtains open.	32	16	30	9
%	46%	35%	37%	35%

Table 29. Daytime light use duration

Descriptives									
		N	Mean (hours)	Std. Dev.	Std. Error	95% Confidence Interval for Mean		Min.	Max.
						Lower Bound	Upper Bound		
Q7: Daytime light use in hours	MH	69	6.94	4.07245	.49027	5.9637	7.9203	.00	14.00
	DDH	46	4.93	3.85517	.56841	3.7899	6.0796	.00	14.00
	PPQ	81	5.91	4.16292	.46255	4.9931	6.8341	.00	14.00
	CC	26	6.23	4.37546	.85810	4.4635	7.9981	.00	14.00
	Total	222	6.06	4.13351	.27742	5.5208	6.6143	.00	14.00

In contrast, DDH architects, despite client constraints to minimize window size for cost reduction (Figure 84) , found the way to well-support occupants’ daylight need. Their solution is to impose well selected minimum daylight level as bottom lines (pg. 194) and resist reducing windows to sizes that would compromise light levels. Additionally, the practice uses bright interior colours to maximize perception of brightness in the room and a staggered design to reduce shading from adjacent building blocks as also noticed by occupants (pg. 95). This may explain why occupant interviews describe the rooms with daylight

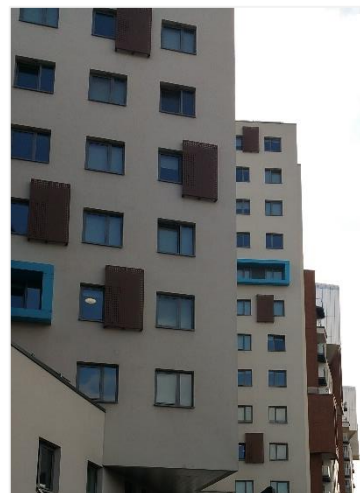


Figure 84. DDH room windows

perceived suitable for work (pg. 94), why it has the best perceived brightness score “Table 30. Perceived brightness for work” and why this accommodation has the lowest average daytime light use duration ,4.9 hours, of all studied sites “Table 29. Daytime light use duration Table”.

The above two contrasting cases may suggest that the architect intention is key to obtaining buildings that support occupant needs and sustainable occupant behaviour. However, the case of CC nuances this conclusion. The architect at CC aimed to provide good visual daylight in the rooms by full-height windows (pg. 193, Figure 85.), however the data shows that occupants perceive the rooms as far less bright than in case of DDH “Table 30. Perceived brightness for work” and also

use the daylight an hour more on average than in DDH “Table 29. Daytime light use duration”. This case suggests that the design intention to support relevant occupant needs may have to be paired with the well-chosen design features to enable occupants to perceive their rooms as bright and support more sustainable use of artificial lights. In this case the culprit may be the width of the window, which the occupants would like to see increased (pg. 94).

Table 30. Perceived brightness for work

Descriptives									
Q3_3 0 Strongly agree 1 Agree 2 Neither agree nor dis. 3 Disagree 4 Strongly disagree		N	Mean score	Std. Dev.	Std. Error	95% Confidence Interval for Mean		Min	Max
						Lower Bound	Upper Bound		
On a typical day, I can read a book without using any of the lights in my room.	MH	69	1.46	1.208	.145	1.17	1.75	0	4
	DDH	46	1.00	.894	.132	.73	1.27	0	4
	PPQ	81	1.53	1.184	.132	1.27	1.79	0	4
	CC	26	1.85	1.255	.246	1.34	2.35	0	4
	Total	222	1.44	1.166	.078	1.28	1.59	0	4

While the design solutions from the above cases are perceived by occupants to be need supportive to various degrees, consideration of floor level in the context of daylight support was missing from architect recounts. This might be of concern since lower floor occupants perceive their rooms as less bright (Figure 39.) and significant correlations also show that the higher the floor level, the brighter rooms are perceived and less artificial light is used (Figure 40.). Thus, floor level may be a feature to be considered in exercises meant to ensure good daylight in student rooms.



Figure 85. Narrow, full-height CC windows

In conclusion, architectural intentions to support occupant need of daylight are common and the tools architects employ to reach this goal are quite varied. However, if the intentions are to materialize in buildings that are perceived by occupants as need supportive, the intentions should pair-up with well-chosen solutions and determination to withstand potential pressure to sacrifice daylight due to client requirements. Nevertheless, in the studied accommodations occupants perceived their room as bright overall, suggesting that architecture may be well on the way to creating good settings for sustainable light use.

Finally, the following design recommendations arise from the study of the accommodations:

- When only modest size windows are applicable, select and abide by good minimum daylight level thresholds;
- When using full-height windows, provide width generous enough to support good perceived daylight levels;
- Consider external factors such as shading from adjacent building when designing for good perceived daylight levels in the rooms;
- Use bright interior surfaces since these might improve the perceived brightness of the space;
- Use judiciously design features such as fixed louvers that might reduce the perceived daylight levels in the rooms;
- Think of floor level when pursuing good natural lighting to prevent lower level residents from perceiving their rooms as darker.

7.3.1.2. Glare discomfort

The overlaps in occupant perceptions based FNB table and the architect intentions based FNB table suggest glare is of significant concern for architects and is also important for occupants. Although the result of the student survey does not reveal a significant correlation between the glare discomfort and the daytime artificial light use (Figure 38.), student interviews suggest that some occupants experience glare discomfort in their rooms, which in turn makes them more likely to close the blinds and to turn on the lights (pg. 98). The survey study quantifies the percentage of students who perceive there is glare in their room at 42% (Table 31. Perceived glare discomfort) and finds that 24%



Figure 86. MH closing blackout blinds to reduce glare

off all students resort to closing the blinds due to glare (Table 7. Frequency table for Reasons of closing blinds during the day.) and 54% of those who close the blinds turn on artificial lighting in the room (Table 8. Frequency table for Reasons of using lights during the day.). Hence discussing how glare perception of occupants is met by design intentions may still be significant for supporting sustainable light use practices by design.

Architect recounts reveal considerations of glare discomfort at the window design of the accommodations however their considerations are not always transferred into the final design solutions in a way that satisfies residents' needs. In cases when architects report simply following BREEAM requirements and provide glare control through blackout blinds only (MH Arch pg.196),

residents of the same accommodation seem to be closing the blinds when affected by glare during work and subsequently switching on the lights (Sione@MH pg. 98).

Table 31. Perceived glare discomfort

Q3_1: On sunny days, there is glare in my room.	N	%	Cumulative %
Strongly agree	21	9.46%	9.46%
Agree	73	32.88%	42.34%
Neither agree nor disagree	49	22.07%	64.41%
Disagree	61	27.48%	91.89%
Strongly disagree	18	8.11%	100.00%
Total	222	100%	

Thus, the very same solution while supportive of resident comfort by reducing glare, seems to reduce the visual comfort of daylight, unintentionally inviting for unsustainable light use (see Figure 86.). A further twist in the design of MH is that the desks are next to the window as a result of architects' attempt to increase light level at the workplace. However, this may also be causing the increased perception of glare at the desk and starting the above behaviour chain of closing the blinds and turning on the light (Nadya@MH pg. 97). In this case the architect does not link the solution devised for providing comfort of reduced glare with the discomfort of reduced brightness or with increased artificial light use behaviours.

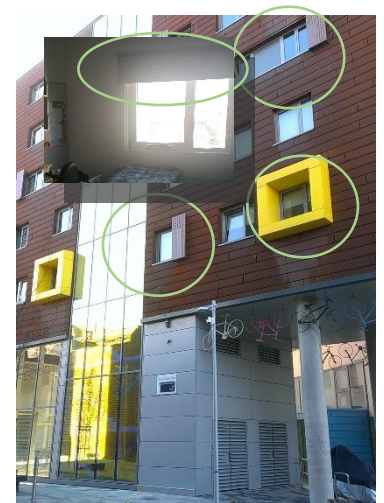


Figure 87. DDH glare control features.

Conversely, when architects associate light use behaviours with glare discomfort and ensure discomfort glare is controllable without sacrificing visual comfort of brightness by the application of a more sophisticated dual system (DDH Arch pg. 195), discomfort glare is missing from occupant interviews. While the architect does not specify the technical solution, they clearly outline the intention to provide occupants a way to control glare without closing off during the day. Nevertheless, based on photographic data gathered on site visits and provided by students it can be summarised that room windows are equipped with blinds and that there are external design features such as perforated panels before the windows or deep window reveals that may be preventive of glare (Figure 87.). The interviewed residents of DDH lack mentioning glare discomfort while there is also mention of working with natural lights without closing the blinds

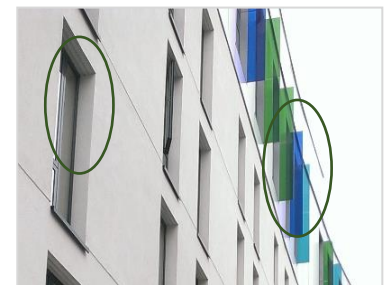


Figure 88. CC glare control features

(Jack@DDH pg. 94), suggesting the above design strategy might have reached its goals.

The CC architect also reports considering light conditions and mentions working with the reveal of the window and with coloured panels to provide shading which may be relevant for glare control (CC Arch pg. 196, Figure 88.). Nevertheless, occupants do not discuss glare, therefore no conclusion can be made on how successful the design solution was in ensuring comfortable levels of perceived glare.

However, the mean scores for perceived brightness in the rooms are fairly uniform across all sites, suggesting that above design solutions are perceived to provide similar level of comfort by occupants “Table 32. Perceived glare in rooms”

In conclusion, considerations for glare enjoys a significant focus in the architectural agenda while the variety of design features employed to provide a comfortable environment seem to yield similar appreciation from occupants. This may mean that architects have a good approach and tools for providing glare-wise comfortable environments to occupants. Finally, an opportunity for further improvement is suggested to be in tackling by design the less sustainable patterns where occupants close the blind due to glare and start using artificial lights.

Design recommendations arising are as follows:

- Provide design features for glare control that are not detrimental to perceived daylight;
- Consider increased glare implications of placing work desks next to windows in student rooms.

Descriptives									
Q3_1 0 Strongly agree 1 Agree 2 Neither agree nor dis. 3 Disagree 4 Strongly disagree	N	Mean score	Std. Dev.	Std. Error	95% Confidence Interval for Mean		Min.	Max	
					Lower Bound	Upper Bound			
On sunny days, there is glare in my room.	MH	69	1.91	1.222	.147	1.62	2.21	0	4
	DDH	46	1.91	.962	.142	1.63	2.20	0	3
	PPQ	81	1.95	1.172	.130	1.69	2.21	0	4
	CC	26	1.85	1.190	.233	1.37	2.33	0	4
	Total	222	1.92	1.143	.077	1.77	2.07	0	4

Table 32. Perceived glare in rooms - descriptives

7.3.1.3. Thermal comfort

This section discusses findings on thermal comfort related to solar heat gains in student rooms since it may impact blind use and daytime light use. Both, the occupant perception based FNB and the architect data based FNB include this aspect of thermal comfort. Since only 10% of occupants

mention closing blinds due to overheating from the sun (pg. 145) it may be that the studied accommodations provide good thermal comfort even on sunny days. Nevertheless, a significant correlation between thermal comfort and blind use indicates that there might still be a detectable pattern among occupants of closing blinds due to solar overheating (Figure 38.).

In DDH for instance, modest size windows - although designed with the primary aim to comply with client dictated financial constraints - are posited by the architect as limiters of heat gain (DDH Arch pg. 197). Furthermore, dual systems for manipulating direct sunshine without closing off during the day are also meant, among other goals, to provide shading from the sun (DDH Arch pg. 195) and therefore can be considered supportive of thermal comfort. While in the interviews, occupants of DDH do not reveal any issues with overheating, overall, based on the survey they perceive their rooms as most prone to overheating from the sun as compared to other accommodations (Mean score:1.91, Table 33. Perceived overheating from the sun), with 43% of occupants finding their room overheats due to the solar gains.

Table 33. Perceived overheating from the sun

Descriptives									
Q3_2		N	Mean scores	Std. Dev.	Std. Error	95% Confidence Interval for Mean		Min	Max
0 Strongly agree						Lower Bound	Upper Bound		
1 Agree									
2 Neither agree nor dis.									
3 Disagree									
4 Strongly disagree									
On sunny days, the sun overheats my room.	MH	69	2.13	1.136	.137	1.86	2.40	0	4
	DDH	46	1.91	1.092	.161	1.59	2.24	0	4
	PPQ	80	1.99	1.258	.141	1.71	2.27	0	4
	CC	26	2.31	1.011	.198	1.90	2.72	0	4
	Total	221	2.05	1.159	.078	1.90	2.21	0	4

However, the issue of overheating related thermal discomfort is not always part of design time considerations (e.g. MH Arch). In those cases, student interviews reveal a considerable dissatisfaction with the room temperature, being experienced hotter than desired and therefore leading to thermal discomfort (Nadya@MH pg. 98). Students identify windows as major features of the environment that might have an influence on their thermal discomfort of excessively hot rooms due to solar overheating and are likely to report restoring their comfort by closing the blinds. The latter behaviour in turn, which seems to often be used to mitigate overheating, is reported to reduce the visual comfort of daylight, making the use of artificial lights more likely. The above finding illustrates how the lack of considering or the lack of providing environmentally appropriate solutions for eliminating or restoring solar overheating related thermal discomfort might not only diminish occupants' thermal comfort but could potentially lead to the

deterioration of daylight visual comfort and eventually may lead to increased daytime artificial light use.

The accommodation that stands out in terms of support for thermal comfort from solar gains is CC. Here the architect considers multiple aspects of the building. First, they reflect over the main construction material and review occupancy periods of student accommodations when they decide to use cross-laminated timber (Figure 89.). Although known by the architect that timber structures may overheat during the summer, this

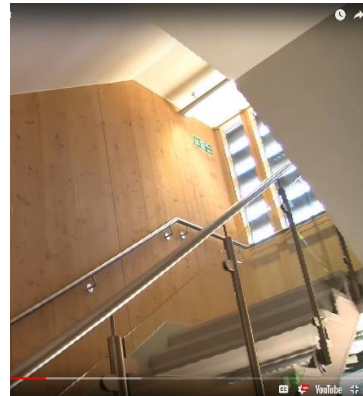


Figure 89. CLT Structure visible in the stair case of CC (CC UAE Presentation,n.d.). YouTube

material is still selected since the accommodations are not in use during the summer and therefore occupant thermal comfort is not believed to be affected (CC Arch pg. 204). In addition, support for thermal comfort is manifested through the design of the windows where the recessed windows are intended to provide shading from the sun (CC Arch pg. 196) and therefore to limit solar heat gain and support thermal comfort. Finally, coloured glazed panels perpendicular to the building surfaces are similarly used to prevent overheating via shading (Figure 88.) and to responds to the client aesthetic requirements, illustrating how well-conceived design solutions can equally be supportive of occupant needs while compliant with client demands. In the above cases, residents are more likely to report high satisfaction with the thermal environment, the lack of overheating related thermal discomfort, and have the most positive assessment of perceived thermal comfort off all studied sites (Mean score 2:31, Table 33. Perceived overheating from the sun), indicating that the architect intentions and efforts were well placed.

Interestingly, overheating related thermal discomfort – just as in the case of daylight visual comfort - is more prevalent in stories of residents living on the upper floors of the accommodations. The survey data analysis confirms that the perceived overheating of student rooms is correlated with floor level, the higher the floor level residents reside the more likely they experience their rooms as hot (Figure 38.). Nevertheless, architects similarly to daylight considerations, do not mention any consideration of floor levels while designing the thermal environment in student rooms (pg. 196 and section 6.3.9 Sustainable heating and ventilation). This is potentially an overall missed opportunity to further improve comfort of occupants and likely increase sustainability of daytime artificial light use.

To sum up, architects of the studied accommodations seem to be well-aware of thermal comfort implications of solar heat gains. In the mirror of occupant perceptions this awareness seems to materialize in balanced buildings, where occupants have an overall positive thermal experience, potentially supporting sustainable light use patterns.

The design recommendations that can be extracted from the studied cases are as follows:

- Aim for solar gain control solutions that reduce overheating without sacrificing natural light levels to a degree that may prompt artificial light use,
- Consider the combination of building fabric, occupancy patterns, window design and shading techniques when aiming to provide good protection from solar overheating;
- Include floor level considerations when designing upper floors of accommodations.

7.3.1.4. Visual Privacy

The case of visual privacy is the first major discrepancy this thesis finds between architect FNB tables and occupant FNB tables, calling for a better understanding of its implications.

While the occupant data reveals the major role visual privacy of not being seen from the outside through the window plays in sustainable daylight use patterns (section “Visual privacy” pg. 95), architect interviews are void of considerations for the same occupant need. On repeated prompts some architects do mention design features such as pathway distances from windows, vegetation in front of the windows, or louvers, which may be protective of occupant privacy (MH Arch). However, these associations were identified during the interview and the features were not applied intentionally to support privacy. Student interviews of the same accommodation confirm this assumption via reports of low visual privacy and pathways perceived as too near the room windows (John@MH pg. 95).

The lack of consideration for privacy is of concern since privacy is significantly related to blind use and light use, suggesting that when residents’ privacy decreases, blind use increases and so does daytime artificial light use. Furthermore, privacy is the most significant predictor of blind use, while 70% of occupants report closing the blinds to re-establish their privacy, and 54% of

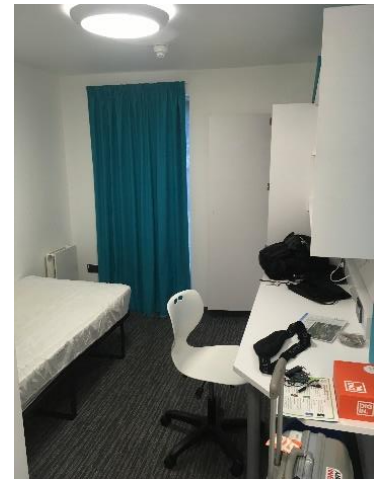


Figure 90. Lights on with curtains closed, CC.



Figure 91. Lights on with closed blinds on ground floor, MH

occupants report turning on the lights since blinds are closed (Section 5.3.1 Light use behaviour in student rooms).

Additionally, the need for visual privacy seems to supersede the need for good perceived daylight levels. When privacy is endangered, students report closing the blinds and thus sacrificing otherwise well appreciated daylight levels, to protect their privacy. The closed blinds reduce the light levels in their rooms which in turn may prompt residents to turn on the lights (Figure 90., Figure 91.).

In the perception of privacy, Floor level plays a significant role again, as in the case of perception of brightness and solar overheating. Privacy concerns are at a higher degree voiced by residents living on the ground floor (pg. 97), and improves as floor level increases (Figure 38.), suggesting that visual privacy might be more fragile on lower floors of the accommodations.

The importance of supporting privacy in student rooms is further exacerbated by the finding that nearly 69% of students perceive their privacy in the room as fragile “Table 34. Perception of privacy 1.” and the overall mean score of 1.23 reflects this “Table 35. Perception of privacy 2.”.

Table 34. Perception of privacy 1.

Frequencies				
		Frequency	Percent	Cumulative Percent
Q3_4: On a typical day, I feel people can see me through the window.	Strongly agree	84	37.8%	37.8%
	Agree	69	31.1%	68.9%
	Neither agree nor disagree	17	7.7%	76.6%
	Disagree	39	17.6%	94.1%
	Strongly disagree	13	5.9%	100.0%
	Total	222	100.0%	

Table 35. Perception of privacy 2.

Descriptives									
Q3_4 0 Strongly agree 1 Agree 2 Neither agree nor disagree 3 Disagree 4 Strongly disagree		N	Mean score	Std. Dev.	Std. Error	95% Confidence Interval for Mean		Min	Max
						Lower Bound	Upper Bound		
On a typical day, I feel people can see me through the window.	MH	69	.94	1.199	.144	.65	1.23	0	4
	DDH	46	1.00	1.054	.155	.69	1.31	0	4
	PPQ	81	1.51	1.380	.153	1.20	1.81	0	4
	CC	26	1.50	1.364	.267	.95	2.05	0	4
	Total	222	1.23	1.281	.086	1.06	1.39	0	4

Thus, support of privacy seems to be a major shortcoming in the studied accommodations and a prime opportunity for architects to significantly improve support for occupant needs and sustainable light use behaviour in the student rooms. Even more so that the lack of support for privacy may trump all other architectural efforts invested in providing good daylight to occupants. While lowest floor rooms are in dire need to receive privacy-protective design features, higher floor rooms cannot and must not be disregarded either.

Overall, recommendations arising from the study of visual privacy are as follows:

- Include systematic support for occupant visual privacy in the architectural agenda of student accommodations;
- Ground floor and lower floor rooms need to be given special focus to support occupants' visual privacy;
- Explore and adopt methods for visual privacy assessments such as sightline studies into rooms or visibility assessments that could potentially predict privacy levels in the rooms.

7.3.1.5. Conclusion

While daylight visual comfort – significantly correlated to light use, and glare discomfort and solar heat gain discomfort – not significantly correlated with light use, are considered and overall well supported by architects, visual privacy – significantly correlated to light use, is missing from the architectural agenda. Further considering that in rooms where daylight comfort need is satisfied while privacy need is missed occupants seem to sacrifice daylight to ensure privacy, it can be suggested that including visual privacy support in design of student rooms might be paramount in enabling residents to capitalize on the benefits of daylight and use the lights more sustainably.

The findings also advise that simultaneous support of the discussed occupant needs may be beneficial for achieving environmentally sustainable daytime light use. Supporting visual privacy by design in ways that do not reduce the comfort afforded by daylight, visual comfort of good perceived daylight levels without creating discomfort glare or overheating related thermal discomfort, improving on design support for glare control and solar overheating control without significant loss of daylight may also facilitate sustainable artificial light use patterns in student rooms during the day.

Additionally, given the relationship between floor level and the perceptions of privacy, visual comfort of brightness, overheating related thermal comfort and light use, special consideration to better supporting visual privacy and visual comfort on lower level floors and thermal comfort on

upper floors by design might be of interest for architects who seek to better promote sustainable light use behaviours in the rooms of sustainable student accommodations.

Finally, based on the cases reviewed in this section an interesting inference starts to take shape. As shown in the case of support for visual comfort or glare, where architects intended to support certain occupant needs residents had a balanced, slightly appreciative perception of the accommodations and behaviours seemed more sustainable. However, for needs outside the radar of architectural intentions, occupant perceptions were slightly negative with less sustainable behaviour patterns associated. This could mean that although architects' intentions to support occupant needs and sustainable light use behaviour might not be enough, it might still be necessary towards developing behaviourally sustainable accommodations.

Hence, in the case of light use in student rooms, the overlaps between the occupant FNB tables and architect FNB tables highlight areas where good architectural practices exist and improvements are a matter of fine-tuning knowledge, understanding or agency of architects, while the gaps between the tables show areas where seems to be a dire necessity for architectural support of occupant needs and a significant potential for improving sustainability of light use patterns.

7.3.2. Light use in kitchens

The present section focuses on artificial light use in the kitchens and dining areas of the sustainable accommodations. It discusses lights use separately from light use in student rooms since kitchens and living areas in student accommodations stand apart in terms of needs occupants express and in light related behaviour patterns that occur. The section is structured around the occupant needs of visual comfort of daylight, of light control, and the comfort of activity matching lighting as perceived by occupants and intended to be supported by architects.

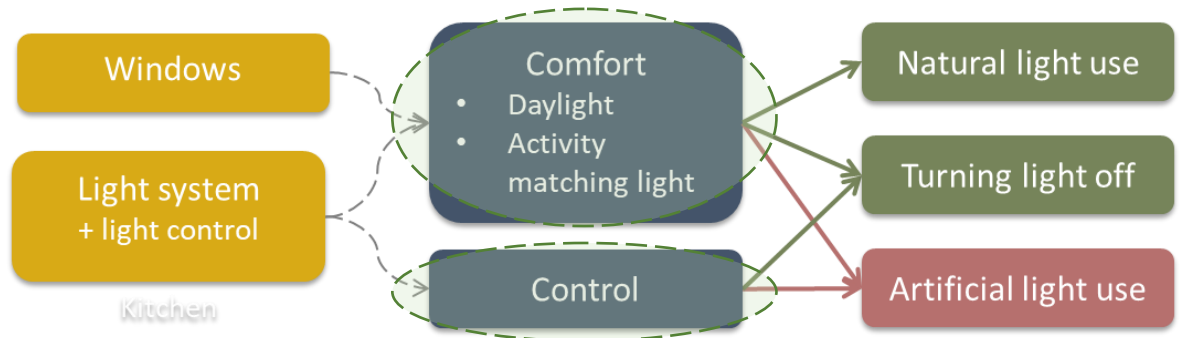


Figure 92. Occupant FNB - Kitchen light use

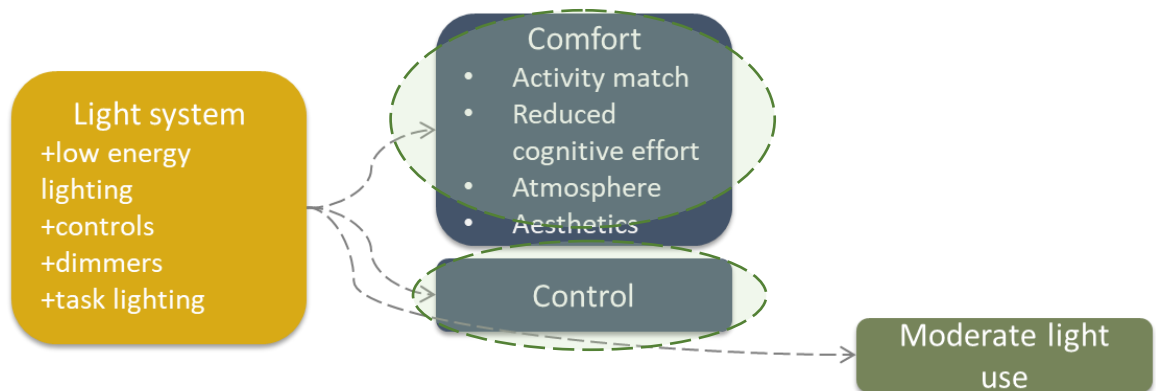


Figure 93. Architect FNB - Kitchen light use

7.3.2.1. Visual comfort of daylight

The occupant FNB map - Figure 92. - and the architect FNB map - Figure 93. - sections related to light use in the kitchens, show an overlap in the area of perceived and intended support for occupant daylight comfort need. The overlap means that occupants use lights in the kitchen more sustainably when their visual comfort is supported (section 5.3.2 Light use behaviour in kitchen and living areas) and that architects also consider support of visual comfort (section 6.3.8 Sustainable light-systems use), potentially well-supporting this significant occupant need and the related light use behaviour. The occupant perceptions of the kitchen brightness confirm this

interpretation by showing that more than 75% of occupants perceive the kitchens as naturally well-lit “Table 36. Perceptions of kitchen brightness”.

Table 36. Perceptions of kitchen brightness

Q10_1. On a typical day there is plenty of natural light in the kitchen, even without the lights on.					
		Frequency	Percent	Valid Percent	Cumulative Percent
	Strongly agree	80	36.0	36.0	36.0%
	Agree	88	39.6	39.6	75.7%
	Neither agree nor disagree	19	8.6	8.6	84.2%
	Disagree	27	12.2	12.2	96.4%
	Strongly disagree	8	3.6	3.6	100.0%
	Total	222	100.0	100.0	

Architects intentionally employ large glazed surfaces in the kitchen and dining areas of the accommodations in order to ensure good daylight levels and provide pleasant views (Figure 94.). These design intentions seem to reach their goal since residents are appreciative of these qualities as student interviews confirm (“Visual comfort of daylight” sub-section of 4.3.2.1 on pg. 104). Besides the design of the windows, the bright interior surfaces of the kitchens and dining spaces are also perceived by the occupants to be supportive of overall brightness of the space.

However, the occupant survey still found that 34% of residents report the need to turn on the lights in the kitchen during the day due to insufficient daylight levels (Table 13. Reasons for using the kitchen lights during the day.). This indicates that design could be potentially further improved to provide brighter kitchen and dining spaces and to reduce artificial light use during the day.

Hence, the design recommendations arising from the study are:

- Design large, glazed surfaces in the kitchens and dining areas of student accommodations since these features are likely to ensure occupants daylight visual comfort and may reduce daytime artificial light use;
- Operate with bright interior surfaces in the kitchen and dining areas to potentially further boost the perceived brightness of the space, leading to more sustainable light use behaviours.



Figure 94. CC & DDH. Glazed surfaces of kitchen areas

7.3.2.2. Control over the lights

The occupant FNB table - Figure 92. - and Architects FNB table - Figure 93. - show overlaps on light control, which suggest that control perceived by occupants to be so crucial for sustainable light use in the kitchens (Table 12. Light use by Control type - Tukey's HSD.) and living rooms are also considered by architects. This overlap signals that the light control may be provided by architects in a manner that is supportive of occupant needs and sustainable light use patterns. However, when looking deeper in the data, a more nuanced conclusion takes shape.

In the case of DDH, the architect reveals integrating automatic controls and omitting any kind of occupant control over the light in the kitchen areas of the accommodations (Figure 95.). As a consequence, occupants report lack of control over the lights and inability to turn off kitchen lights not even in the brightest natural light conditions (*Jaden@DDH* on pg. 104), making DDH use statistically significantly more light than all other studied accommodations



Figure 95. DDH lights on in broad daylight.

“Table 37. DDH using significantly more light in the kitchen”, “Table 11. Kitchen light use by Control type – One-way ANOVA.”, and Figure 45. The lack of control over the light environment and the concomitant outcome of not being able to have and set the desired light levels - mentioned by occupants - is acknowledged by architects as factors potentially detrimental to occupant comfort needs. More specifically, there is acknowledgment that enabling occupants to granularly control or dim the lights is supportive of comfort and may result in lower light use (DDH Arch pg. 201). However, despite the understanding of light environments, occupant needs, light use, and the relationship between these dimensions in the context of student accommodations, the architect chooses to engineer out occupant control (DDH Arch pg. 201).

Table 37. DDH using significantly more light in the kitchen

Multiple Comparisons								
Dependent Variable		(I) Q48_ Site	(J) Q48_ Site	Mean Difference (I-J) (hours)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Q12_1 Cumulative_Light_Use Kitchen Day	Tukey HSD	DDH	MH	+2.4	.80456	.015	.3446	4.5105
			PPQ	+2.3	.78036	.018	.2859	4.3265
			CC	+4.6	1.03708	.000	1.9237	7.2937

The interview data suggests that overall architects consider the benefits of automatic light controls outweigh the shortcomings. Adding automatic controls – with or without manual controls – to the light control strategy is deemed by architects to be energy efficient due to its

nature of automatically switching off lights when the space is vacated, preventing as such the unwanted and unsustainable behaviour of leaving the lights on (DDH & MH Arch in section 6.3.8 Sustainable light-systems use). Apart from being considered as supportive of sustainable light use behaviour, resident comfort is also believed to be supported by making the sustainable choice effortless to residents and removing the burden of having to remember to turn off the lights when leaving the space. Furthermore, architects report considering occupant comfort by choosing the light system according to the dynamics of anticipated occupant activities performed in a space. Their guiding principle is to apply automatic motion sensor based light controls where the discomfort of having the lights turn off unexpectedly can be minimized or avoided. The communal areas are thought to accommodate activities that require constant movement, thus the risk for occupant discomfort of having the lights turn off unwantedly is negligible in architects' perspective.

The fact that resident interviews lack reports on discomfort created by the lights that turn off unexpectedly or on the burden of having to remember to turn off the lights when vacating the kitchen and dining space suggests that these aspects of comfort needs are successfully supported by design, with the potential in-built benefit of reducing wasteful light use behaviours and practices. However, without providing some degree of control to residents the potential energy savings seem to be missed and significantly more intensive light use can be predicted (Figure 45., Table 37. DDH using significantly more light in the kitchen).

In conclusion, architects seem to have a good understanding on how to create light control strategies that are perceived by occupants to support their needs and may help them use lights sustainably during the day. However, the case of DDH underlines that this understanding must be put in practice well if the sustainable building are to deliver their sustainable behavioural goals.

The main design recommendations arising from the study are:

- Technology should be complemented with human agency in light control systems of sustainable accommodations.
- Use motion sensor based light controls (in addition to manual controls!) in spaces abundant in occupant activity and movement.

7.3.2.3. *Comfort of activity matching light conditions*

The occupant FNB table - Figure 92. - and the architect FNB table - Figure 93. - sections related to light use in the kitchens intersect in the area of perceived and intended support for activity matching comfort need. The overlap may mean that while occupants use lights in the kitchen

more sustainably when their comfort of activity matching light conditions is supported, architects also consider support of the same need, potentially well-supporting this significant occupant need and the related light use behaviours (Figure 96, Figure 97).

More specifically, student interviews suggest frequent cases where occupants do not need the artificial lights on or would need dimmed lights that match the activities performed in the kitchen and dining spaces after sunset. The Occupant Survey Study quantifies this phenomenon and indicate that 77% of residents would want to turn off the lights during the evening for the comfortable enactment of various social activities such as watching movies, playing video games or partying (Table 14. Evening time activities requiring reduced lighting.).



Figure 96. Group dinner in CC

Architect recounts seem to match this understanding since one participating architect discusses extensively the lights and light control systems, occupant comfort it might affect while occupants perform actions specific to accommodations, and the potentially consequences on artificial light use (DDH Arch in section 6.3.8 Sustainable light-systems use). Nevertheless, the very same participant admits to using a simplistic light control system, namely a fully automatic control, due to affordability concerns raised by the client. This results in the inability of residents



Figure 97. TV space next to dining area in the evening. MH.

to turn off or dim the lights, which besides reducing their comfort of activity-matching light conditions. In an attempt to restore their comfort residents report ways to circumvent the system and apply tape over the motion sensors (Harry@DDH pg.107). This behaviour is confirmed to be prevalent by the survey since 60% of occupants who lack control over the lights and want to switch off or dim the lights during the evening, report restoring their comfort by taping the sensors (pg. 154). Moreover, DDH where kitchens only have automatic light controls exhibits statistically significantly more sensor taping than any other studied site “Table 38. Significantly more frequent sensor covering in DDH” while DDH is also where students are the most active during evening hours and would want to have lower light levels the most often “Table 39.DDH occupant demand more often lower light levels during evening”.

While circumventing the system and taping the sensors could ironically be considered as using the lights more sustainably compared to the use allowed by the original design, the same behavioural reaction also poses safety hazards and should not be encouraged by any design means.

Table 38. Significantly more frequent sensor covering in DDH

Multiple Comparisons									
Dependent Variable		Site (I)	Site (J)	Mean freq. of covering sensor	Mean Diff (I-J) (%)	Std. Error	Sig.	95% Confidence Interval	
								Lower Bound	Upper Bound
Frequency of covering sensors to turn of lights in kitchen	Tukey HSD	DDH (65%)	MH	0%	.652*	.044	.000	.54	.76
			PPQ	0%	.652*	.042	.000	.54	.76
			CC	4%	.614*	.056	.000	.47	.76

Table 39. DDH occupant demand more often lower light levels during evening

Descriptives									
Values 0: <2x / month 1: 2-4x / month 2: 5-9x / month 3: >10x / month		N	Mean score	Std. Dev.	Std. Error	95% Confidence Interval for Mean		Min	Max
						Lower Bound	Upper Bound		
Frequency of wanting the lights off in the kitchen during evenings	MH	63	1.03	.983	.124	.78	1.28	0	3
	DDH	46	1.65	1.016	.150	1.35	1.95	0	3
	PPQ	80	1.36	1.022	.114	1.14	1.59	0	3
	CC	17	.47	.717	.174	.10	.84	0	2
	Total	206	1.25	1.033	.072	1.11	1.39	0	3

Here the core issue seems not a disconnect between architect understanding or consideration and occupant perception, but rather between acknowledged occupant needs and circumstances outside the architects’ agency that prevent them from designing the building in a way they know would support occupant needs. Thus, the overlap in the FNB tables indicates well the good match between occupant perception and architect intentions, while the interpretation of the underlying qualitative and quantitative data indicates a disconnect which may be conducive of lower occupant comfort and safety hazards and which may need to be bridged to ensure sustainable accommodations are more comfortable, sustainable behaviour supportive and safe.

In addition, occupants recount of other mundane, nocturnal behaviours where turning all lights on is not needed. The automatic lights turn on nevertheless generating energy waste. For instance, popping out from the room for a glass of water is such an activity (Harry@DDH pg. 107), but many more can be envisaged. Although only further research could better quantify the impact of these mundane actions, it can be assumed that the cumulative time the automatic lights turn on and remain on in such cases amounts to significant waste.

Overall, design recommendations arising from the study of activity matching light comfort and the potentially related light use behaviours in the kitchens and dining areas of student accommodations are as follows:

- Lighting in the kitchens and dining areas of student accommodations should cater for a plethora of activities which require reduced light levels during the evening;
- Light controls in kitchen and dining areas of accommodations should include manual controls to allow residents to switch off the lights if that better matches the comfortable enactment of their activities, concomitantly supporting sustainable light use;
- Studies such as the present investigation should be used to gauge the extent of occupant discomfort, safety hazard and energy waste that comes with the reportedly more simplistic and cheaper, fully automatic light systems and light controls, to counterbalance the cost rhetoric, and to promote the use of slightly more elaborate and probably marginally more expensive but more occupant-need supportive and likely more behaviourally sustainable light systems.

7.3.2.4. Conclusion

The positive overlaps of occupant and architect FNB tables in the area of light use in the kitchen suggests that architects of sustainable accommodations can already design spaces that are perceived by occupants to be need supportive, and likely promote sustainable light use patterns. Occupant comfort consideration and light control strategies that fit occupant needs are both within reach of knowledge and know-how of architects.

However, the underlying data also shows that occasionally there are obstacles other than architect intention and knowledge in front of realizing well-informed design intentions. Therefore, the opportunities for improvement applicable in this area may be in the realm of policy making and formalized design support for occupant needs. Alternatively, understanding what are the safety hazards and energy waste risks associated with not supporting occupant needs by design, may help sway decision makers to invest in adequate support for occupant needs.

7.3.3. Heating and ventilation

Heating and ventilation behaviours often appear intertwined in student accounts and are therefore discussed together by the present section. The section is structured around the needs of thermal comfort, control over the thermal environment, comfort of air quality, and control over the ventilation, needs that may be related to sustainability of heating and ventilation practices.

While thermal comfort and the comfort of air quality is discussed based on data from all three empirical studies, the discussion of ease of use of controls over the thermal environment and control of ventilation is performed based on Student and Architect interview data solely. These two occurrences of ease of use need were not part of the student survey due to space limitations.

7.3.3.1. Thermal comfort

Juxtaposition of the Occupant FNB - Figure 98. - and Architect FNB map - Figure 99. - reveals an overlap in the area of thermal comfort considerations, suggesting that architects may be already tackling some aspects of this occupant need likely significant for the sustainable use of the accommodation. However, the occupant data revealed that satisfying thermal comfort of occupants incorporates various scenarios and a comparison with how architects may consider those scenarios may be necessary to identify good practices or opportunities for improvement.

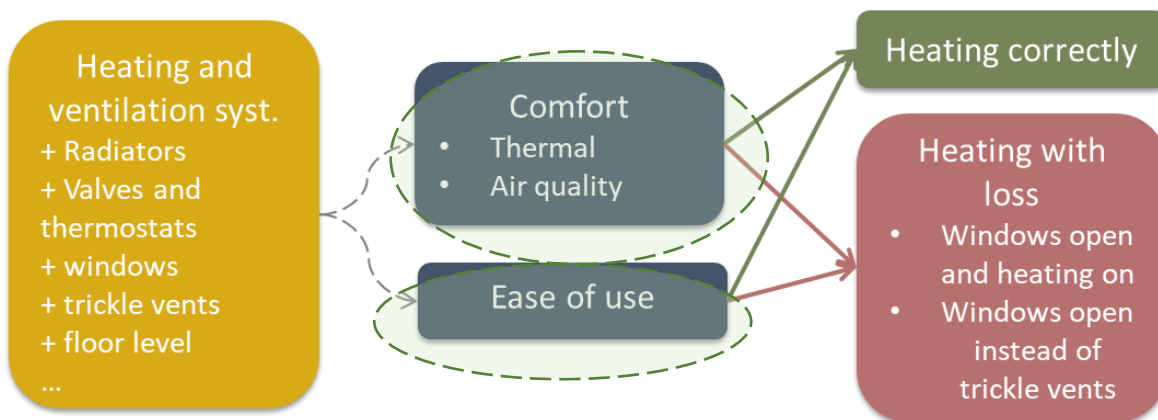


Figure 98. Occupant FNB - heating & ventilation

First, occupant interviews suggests that heating practices in the rooms of the studied accommodations are shaped by how far the design features serve occupant needs of indoor thermal comfort of sufficiently warm rooms (subsection “Thermal comfort” on pg. 109, Figure 100). When design features cater for this type of thermal comfort, occupants are likely to report more sustainable heating practices. By contrast, where the same resident needs are not well supported, the reported heating behaviours are likely to be more energy intensive.

The occupant survey supports the inferences via statistically significant correlations between self-reported duration and intensity of radiator use and perceived temperature in student rooms. The colder residents perceive their rooms, the longer and more intensive the reported radiator use. Conversely, the more residents perceive their rooms having the desirable temperature, the milder heating practices are reported to be. Furthermore, floor level is found to relate significantly to heating practices, more specifically to heating duration. The higher students reside in the building, the shorter the time the radiators are in use (Figure 48.).

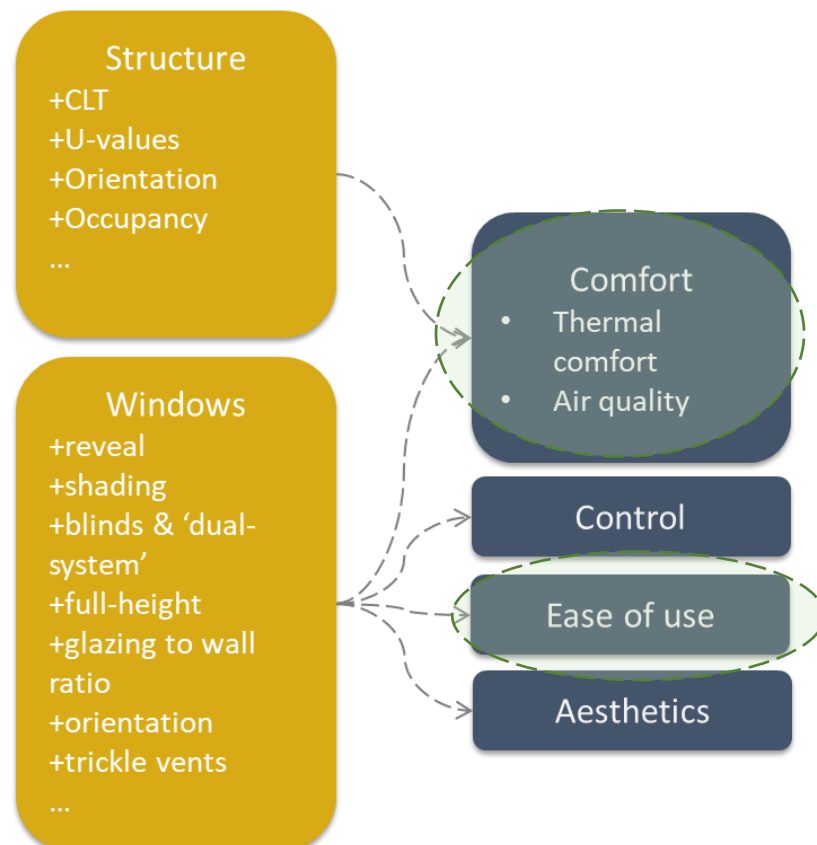


Figure 99. Architect FNB - heating & ventilation

On the other hand, architectural interviews are oblivious of considerations for sufficiently warm rooms, for occupant heating practices or for changes in heating behaviours across floor levels. This doesn't mean that architects are not concerned at all with the thermal characteristics of the accommodations. However, the considerations of thermal characteristics constitutes more of building physics based engineering exercise rather than an exercise of bespoke



Figure 100. Using radiators in MH

consideration of occupant needs and sustainability of subsequent behaviours. This might be the

reason why the thermal environment is considered appropriate by less than half (44%) of the residents of all accommodations with the remaining residents perceiving their room as either cold or hot (see white line on Figure 101.).

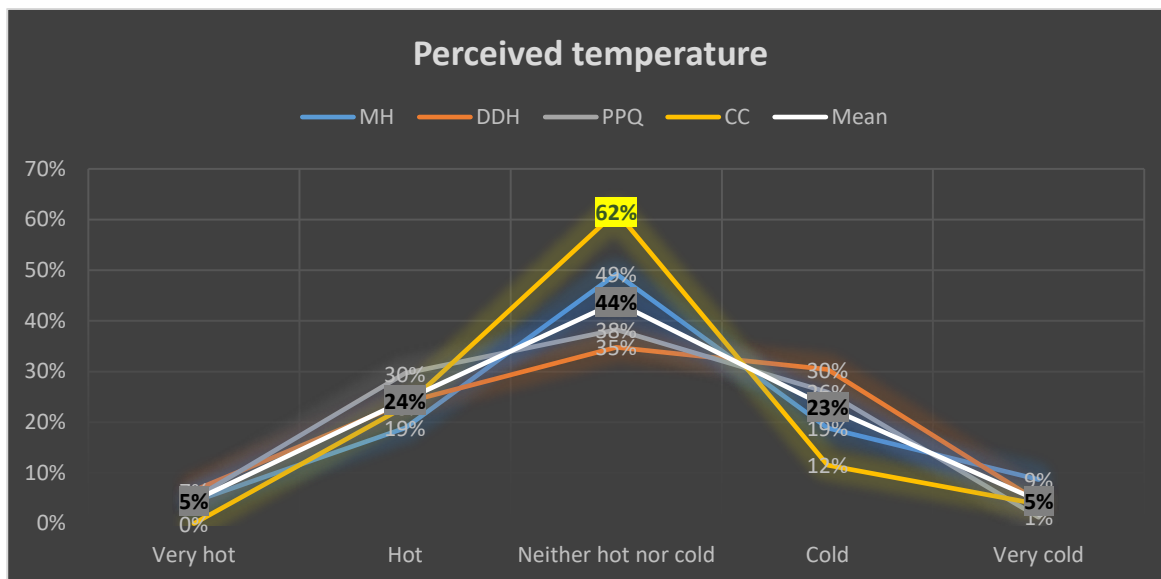


Figure 101. Perceived temperature by accommodation

Paradoxically, overly hot environments also seem to be conducive of more intensive and unsustainable heating behaviours. When the radiators are perceived by residents to heat up the rooms too suddenly it is likely that residents proceed to calibrating the room temperature and restoring thermal comfort by opening the windows while the radiator is on (pg. 109) which is extremely energy wasteful. The high prevalence of the practice of heating with open windows is supported by the survey analysis revealing that nearly 24% of residents keep the windows open while the radiator is on because the radiator overheats their rooms (Table 18. Reasons for heating with open windows. ref Survey). The survey analysis further indicates that heating with open windows is significantly correlated with both heating time and radiator settings (Figure 48.), underlining that this type of heating practice, increases the duration and the intensity at which the radiator is used.

Hence ideally, the design should allow as many occupants as possible to perceive their rooms as neither hot neither cold. From this perspective CC, plotted with yellow line in Figure 101., stands out from other studied sites since 62% of its participating residents perceive their room temperatures as well-balanced.

Despite the high prevalence of heating with open windows in the studied accommodations and its well obvious energy wasteful character, architects do not mention considering nor aiming to

prevent this extremely unsustainable practice through design. This doesn't mean that architectural considerations do not include at all thermal comfort of occupants. Architects do consider thermal comfort of occupants in various ways. These are just not the considerations that match the findings of the occupant data analysis in the context of heating and ventilation practices in sustainable accommodations.

For instance, at the selection of the main construction material, architects consider the occupancy periods of the accommodations, when they decide to use cross-laminated timber. Although known that timber structures may overheat during the summer, this material is still selected since the accommodations are not in use during the summer and therefore occupant thermal comfort is not affected (CC Arch. pg. 204). In addition, supporting thermal comfort is manifested through the design of the windows. Architects employ recessed windows with the intention to provide shading from the sun (CC Arch. pg. 196) and therefore to limit solar heat gain and support thermal comfort. Alternatively, modest size windows - although designed with the primary aim to comply with client-dictated financial constraints - are also posited by the architect as limiters of heat gains (DDH Arch pg. 197). Furthermore, dual systems for manipulating direct sunshine without closing off with blinds during the day - are also meant, among other goals, to provide shading from the sun (DDH Arch pg. 195) and therefore can be considered supportive of occupants' thermal comfort. Finally, coloured glazed panels perpendicular to the building surfaces are also used to prevent overheating via shading (CC ARCH pg. 196) and to respond to the client aesthetic requirements, illustrating how well-conceived design solutions can equally be supportive of occupant needs while compliant with client demands.

The gap is solely with the fact that the supported occupant needs and the circumstances in which those needs are supported are not the ones that seem to be conducive to less energy intensive heating and ventilation behaviours.

The design recommendations arising from the study on the support of thermal comfort needs and its associations with heating and ventilation in the context of student rooms are the following:

- Design of sustainable accommodations should aim to support thermal comfort of occupants by avoiding both cold rooms and overly hot rooms since both may be conducive of energy intensive heating patterns;
- Sustainable accommodation design needs to acknowledge the accommodation specific and highly energy wasteful occupant practice of heating with open windows, and design thermal

environments where occupants are not driven to engage in this behaviour since their thermal comfort need is well supported;

- The design of thermal environments should consider the phenomena of higher perceived temperatures on higher floor levels and be aware that lower floors might be perceived as colder by occupants.

7.3.3.2. *Ease of use of controls over the thermal environment*

The FNB tables constructed from architect data shows overlaps in considerations for the ease of use of controls of the thermal environment with the same area of the occupant FNB table, as visible from the architect FNB table - Figure 99. - and occupant FNB table - Figure 98.

On the occupant side, the student interviews suggest that residents may find it challenging to control the thermal environment in their rooms (sub-section “Ease of use of heating controls” of 4.3.2.2 on pg. 111). While they can open the windows, although only partially due to safety conventions specific to UK student residences, some students may have difficulties in controlling the radiators. The lack of ease of use in controlling the radiators, might easily contribute to thermal discomfort, which may impact sustainability of heating practices.

Architects discussing heating controls report provisioning radiators with adjustable valves commonly used in residential projects, which in their view enables residents to easily control the temperature in the rooms and achieve thermal comfort (MH Arch pg. 204). The occupant recounts of the same accommodation echo the architect intention since students find the controls “box standard” (John@MH pg. 111). However, based on resident survey data, the operation of some of the studied accommodations seems to override the intended design solution and substitute that with a solution that reduces occupant agency and control over the heating by supplying heating at set times of the day. Although this latter solution might appear to have heating energy reduction benefits, it may be detrimental to student comfort via rooms experienced as cold. Moreover, residents may restore their comfort by circumventing the time-rationed heating system with the use of electric radiators, with 33% of all residents using such devices. Thus, the centrally controlled, rationed heating may easily lose its expected energy saving benefits while it affects student comfort and contributes to fire safety hazards increased by the electric radiator use.

Therefore, the design recommendations of this section focusing on how the support for control over thermal environment might lead to sustainable heating practices in the rooms of sustainable student accommodations are the following:

- Integrating occupant control need supportive heating systems in the architectural design of student rooms and enabling occupant agency over the indoor temperatures might lead to safer, more comfortable, and likely more sustainable heating practices in the rooms of sustainable student accommodations;
- Studies such as the present investigation should inform operation of the accommodations on the extent of occupant discomfort and safety hazard posed by rationed heating, arguing that rationed heating is likely failing to deliver any expected energy and cost savings.

7.3.3.3. *Comfort of good air quality*

Air quality considerations have a marked presence on both architect and occupant FNB tables potentially signalling architectural practices that match occupant needs and support sustainable occupant behaviour (see Figure 99. and Figure 98.).

Student interviews suggest that the support of good perceived air quality need leads to more sustainable ventilation practices in the rooms of sustainable student accommodations. When students perceive the air in their rooms as fresh, they only report opening the window when the temperatures are experienced as too hot, and consequently they want to cool off their rooms, but not for airing the room (subsection “Comfort of good air quality” of 4.3.2.2 on pg.112). In case the radiator is on, the same residents report switching off the radiators while the windows are open. However, when the air is perceived as stuffy, residents report opening the window to air their room and in case the radiator is on they leave it on while the window is open. The latter way of airing the room while maintaining the desired room temperature is unequivocally more energy wasteful.

As presented in the “7.3.3.1 Thermal comfort” subsection, opening the windows while the heating is on shows significant correlations with both heating time and intensity, suggesting that the practice of simultaneous heating and ventilation leads to less sustainable heating practices. Although in the previous subsection this behavioural reaction is attributed to thermal discomfort, the fact that 50,9% of residents reason opening the windows while the radiator is on with the air being perceived stuffy with closed windows (Table 18. Reasons for heating with open windows.), supports the inferences of the student interviews mentioned above and suggests that perceived air quality might also be a significant contributor to swaying sustainability of heating and ventilation practices.

Surprisingly, the survey analysis does not provide correlational support for the qualitative inferences of the occupant interview study and does not find significant correlations between

most of the measured perceived air quality components - freshness, humidity or airflow, and ventilation practices. On the other hand, the survey data indicates that the air humidity component of perceived air quality, significantly correlates with intensity and duration of heating behaviours and practices. The dryer the air in the room is perceived the higher the radiator use duration and intensity and hence the more unsustainable the heating behaviours are (Figure 48.). This finding is paradoxical since it seems to be in contrast with the fact that humid air may need more energy to be heated up to the same temperature. Nevertheless, this study focuses on how residents perceive the air quality in their rooms and how those perceptions might lead to sustainable heating practices. It may well be possible that since dry air is perceived less warm than humid air, occupants heat the air of their room to higher temperatures to experience thermal comfort.

Architects report understanding how “stale” the air can become in student accommodations and aim to provide good ventilation through full-height windows and trickle vents installed on or sunk into window frames (subsection “Comfort and control of indoor air quality” of 6.3.9 on pg. 205). Although the comfort of good perceived air quality is not explicitly stated in architects’ accounts, it can be assumed that the intention to provide good ventilation is implicit for supporting the air quality component of comfort. In these cases, residents report good air flow in their rooms (sub-

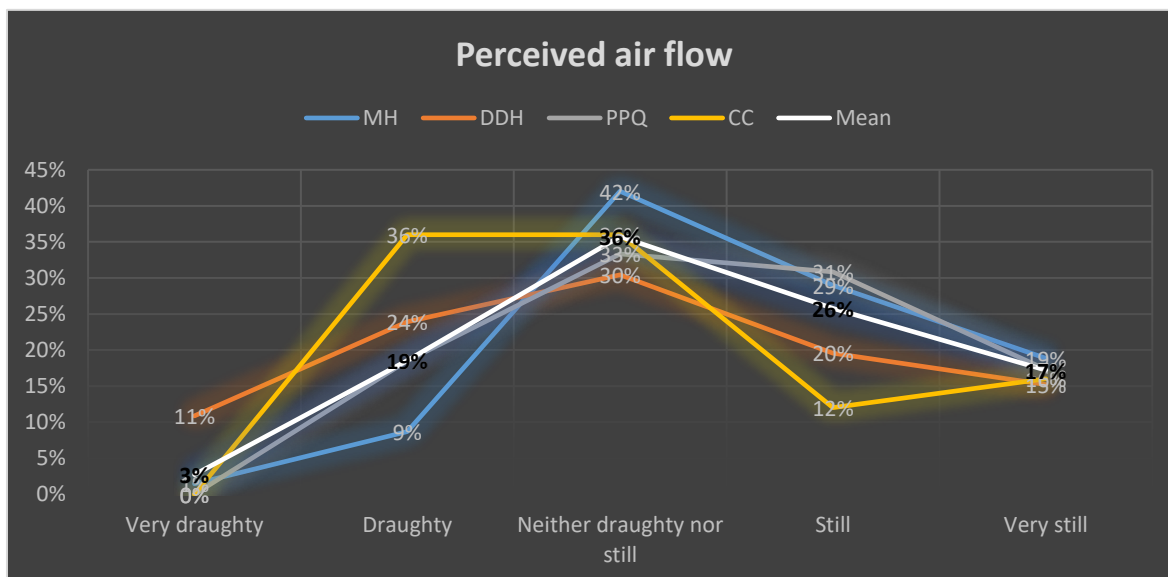


Figure 102. Perceived air flow by accommodation

section “Comfort of good air quality” of 4.3.2.2 on pg.112) as also reflected in the plots of perceived air flow: see the orange and yellow lines on Figure 102. that show how the residents of CC(yellow) and DDH(orange) are the least likely to perceive the air as still or very still.

However, there are accommodations where student report “still” or “suffocating” air (Susan@MH pg. 112), suggesting the ventilation is wanting. In this latter case the architect aim to ensure ventilation via openable windows, however they also install fixed louvers to prevent students from littering through the window, potentially obstructing ventilation(MH Arch pg. 198). The fact that residents of the same accommodations also recount engaging in the energy wasteful heating and ventilation practice of opening the windows while the heating is on (John@MH pg. 113) further enforces the assumption that design support for good air quality might be key to sustainable heating and ventilation behaviours.

Although all participating architects considered ventilation in student rooms, some more occupant need supportively than others, none of them explicitly link it to perceived air quality, differentiate between different aspects of air quality, such as freshness, humidity or airflow and none of them link it to heating and ventilation practices, this later being visible from Figure 99. However, when they intend to cater for ventilation and their intentions are not obstructed by competing requirements, occupants likely perceive the air quality to be noticeably less still and may potentially act more sustainably.

In conclusion, the recommendations suggested by the study on the comfort of good air quality in student rooms are the following:

- Perceived indoor air quality is an abstract concept to occupants and designers alike, suggesting that cross-disciplinary collaboration might be necessary to better understand how to support this occupant need by design, with the aim of improving sustainability of heating and ventilation behaviours, as well as enhancing occupant comfort;
- Features such as full-height windows and trickle vents might support resident comfort of good air quality and might promote more sustainable heating practices therefore their use is recommended;
- The practice of heating with open windows and its potential roots in poor perceived air quality needs to be considered during architectural design since it is a highly energy wasteful practice which is extremely salient in student accommodations.

7.3.3.4. *Ease of use of control over air quality*

Residents of several studied accommodations face difficulties with controlling the ventilation devices, more specifically the trickle vents, at the time of their arrival (sub-section “Ease of use of ventilation devices” of 4.3.2.2 on pg. 113). As new occupants, they are either unaware about the presence of trickle vents or experience difficulties in understanding how to correctly use these

features. The lack of recognizability and ease of use leads residents to fail to capitalize on the benefits of the trickle vents: they cannot start the vents nor stop those, the latter putting a strain on their health in cold weather. Furthermore, not being able to limit the stream of cold air may also result in decreased thermal comfort of cold rooms, which in turn as suggested in the “7.3.3.1 Thermal comfort” subsection, may lead to more intensive heating. Conversely the inability to start the trickle vents and allow in fresh air may lead to overly hot rooms which may lead to resident discomfort and unsustainable heating and ventilation practices of heating with open windows (see “7.3.3.1 Thermal comfort” subsection).

Although architects mention aesthetic considerations at the design of the trickle vents and aim to make those less visible or hide those into the window frame (pg. 205), concerns around recognizability and the ease of use contributing to lack of support for control needs is not present in their accounts. Nevertheless, occupant data makes it observable that control over the trickle vents should be better considered during design. This is not to say that supporting aesthetic needs are less important than recognizability and ease of use. Instead the contention of the study is that by designing natural ventilation devices that are easily recognizable and ensure intuitive use while also supportive of aesthetic needs, might better serve occupant air quality control needs while potentially reducing energy intensive heating and ventilation practices.

Overall, design recommendations arising from the study of design satisfaction of occupant control needs over the natural ventilation devices and its potential relationship to heating and ventilation practices in student rooms of the sustainable accommodation are as follows:

- Extending the need support of control over ventilation devices with support for recognizability and ease of use is advisable in order to provide more intuitive control over ventilation to residents, enhance occupant thermal and air quality comfort, contribute to more sustainable heating and ventilation practices while also protecting residents’ health.

7.3.3.5. Conclusion

Both thermal comfort and air quality comfort - significantly related to heating behaviours - are prevalent in occupant recounts and in architectural considerations of designing the rooms of sustainable student accommodations. Nevertheless, the thermal comfort residents report to expect and the thermal comfort architects afford through the design of rooms presents considerable mismatches potentially resulting in more energy intensive heating and ventilation behaviour. Similarly, air quality comfort is intended to be supported by architects, however students often find this need unfulfilled possibly resulting in wasteful heating and ventilation

practices. The section also highlights the distinctly unsustainable practice of simultaneously heating and ventilating the room, highly ubiquitous in student residences, which is not mentioned by architects. Therefore, it is the contention of this study that by properly supporting the needs for thermal comfort and good perceived air quality in the design of student accommodation rooms might significantly reduce wasteful heating and ventilation practices and consequently improve the overall performance of the sustainable accommodations.

Given the relationship between thermal comfort, floor level and heating time, special consideration to supporting thermal comfort on lower floors by design might be of interest for architects who seek to better promote sustainable heating behaviours in the rooms of sustainable student accommodations.

Finally, occupant need for control over air quality, although considered in architectural design, would likely need to integrate improved features for recognisability and ease of use if environmentally considerate heating and ventilation behaviours, good occupant comfort and health is pursued by design. On the other hand, control over the heating seems to be well-supported by design of the studied sustainable accommodations.

However, supporting occupant need for thermal comfort and control over the thermal environment may be beyond architects' agency. Data collected shows that accommodation providers resort to rationing heat, which impacts occupant comfort and control needs and prompts residents to use additional electric heating devices, denying energy savings and increasing fire safety risks. Thus, the design time consideration for occupant needs of thermal comfort and control over the heating may have to be extended to operation of the building if sustainable heating practices are to be achieved in sustainable accommodations.

7.3.4. Recycling behaviours

The present section focuses on waste management and recycling behaviours in the rooms, kitchens and communal areas of the sustainable accommodations. The section is structured around the occupant needs of comfort, ease of use and hygiene which emerged as likely conducive of recycling behaviours.

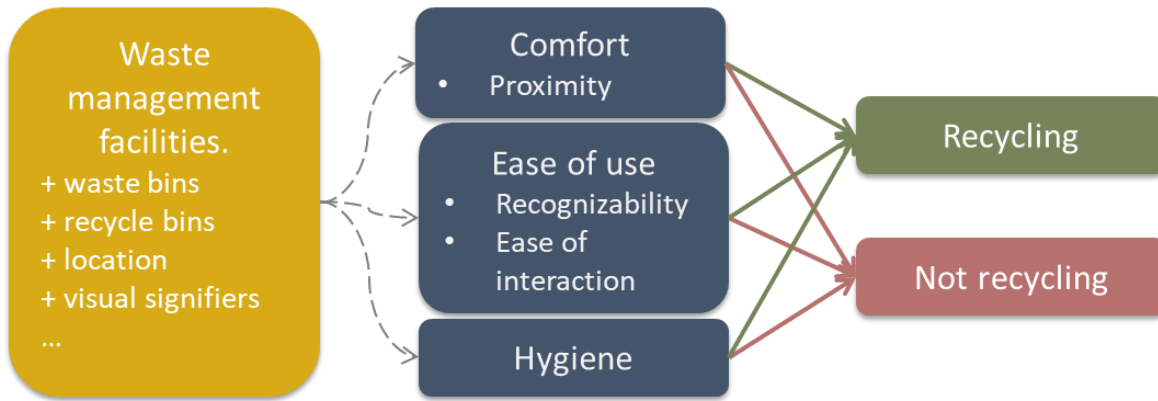


Figure 103. Occupant FNB - Waste management



Figure 104. Architect FNB - Waste management

7.3.4.1. Ease of use

Ease of use presents itself in the student interviews as an occupant need likely related to recycling behaviours (section 4.3.2.4 Waste management and recycling). Furthermore, it appears to be composed of perceived visual differences aiding the function recognition of the facilities, and of perceived ease of using the waste management facilities.

The visual differences between waste bins yields significant correlations with recycling activities (Figure 51.). The more visually different the waste receptacles are perceived the more frequent and correct the reported recycling practices are, hinting that visual differences might help occupants recognise the function of the waste bins. The visual differences that most correlated with recycling behaviour are: the size of the bins, shape of the bins, colour of the bins and the colour of the installed bags (pg. 166). In addition, 75% of respondents who recycle report their behaviour is facilitated by visual instructions on the bins, with 39.7% marking bin colours as

facilitators and 6.4% marking bin size (Table 26. Design Features aiding waste separation.). Despite the high percentage of students identifying the visual instructions as facilitators of recycling, the plain presence of visual instructions does not show significant correlations with recycling behaviours (pg. 166). Nevertheless, student interviews suggest that when the visual instructions on receptacles are clear, recycling behaviour is more salient (pg. 120), suggesting that clear visual instructions may also be facilitators of recycling behaviours besides the shape, size and colour of the bins and the colour of the bags.

Although the visual differences of the bins may help suggest where to dispose of waste, the student interviews propose that ease of use is not necessarily the function of visual differences. The bins may be perceived as visually different and guiding of recycling, however the perceived ease of use seemingly independent of the visual guidance, might interfere with recycling (sub-section "Ease of use – interaction with the bins" of 4.3.2.4 on pg. 121). In some cases, the bins in the communal areas of the student flats incorporate two openings of different size, shape and colour. The larger, green opening is expected to be used for recycling while the smaller, black opening is meant to be used for refuse waste (Figure 31.). However, student recounts reveal that although recycling in principle would be easy, given that the function of the bins is clear, the design may not be supportive of perceived ease of use. Disposing of the general waste is perceived to be cumbersome via the small openings and refuse waste is hence disposed of through the larger opening originally intended for recycling. In another case, the architectural design integrates waste disposal shafts in the exterior of the buildings, well-differentiated via separation, colour and labels (Figure 29.). Students confirm recognizing where different waste types are expected to be dropped off, however separation doesn't happen due to the lack of perceived ease of use. Since shaft lids open only partially and even more, waste bags do not fit through the openings occupants, report simply dropping the waste bags next to the shafts (Andy@PPQ pg. 122). This latter reaction is not only hindering recycling but generate littering and disrupts waste management.

The relationship between the perceived ease of use and recycling behaviour is reinforced by the quantitative study via statistically significant correlations between perceived ease of use of the waste bins, and frequency and correctness of recycling behaviours (Figure 51.). The easier residents perceive recycling is afforded by the waste bins, the more frequent and the more correct their recycling practices. Conversely, the less easy waste bins use is perceived, the less frequent and correct the recycling practices. Overall, 43.7% of respondents report to recycle because it is easy. Therefore, the assumption that perceived ease of use and function recognition

are independent components of ease of use need, is supported by the quantitative analysis which did not find significant relationships between the perceived ease of using the facilities and the perceived visual differences of the facilities.

Architect interviews are short on data related to the visual instructions or perceived ease of use of the receptacles and on design intentions to support overall ease of use of waste management facilities. This suggests the design of these objects is not on architects' agenda, or at least not at this granularity. Nevertheless, the observation of the waste management facilities during site visits and photo documentations provided by some residents, allow a discussion on the final design of the facilities and allows the researcher to build an interpretative framework on potential design intentions. The observations and photo documentations show that the accommodations are equipped with a variety of waste receptacles which may be separated by waste type, may differ in the size, shape or colour of the openings or in the size, shape and colour of the bins, and may have visual instructions applied on their side or above the bins on the wall informing residents on the correct use. The variety of bins and the presence of visual instructions suggest the design – product design and architectural design in this case – incorporate intentions to make the function of the facilities clear and easy to use. Nevertheless, these design intentions do not always seem to match their goals given residents often report scant recycling behaviours and practices.

In conclusion, the key recommendation arising from the present section is that:

- design of recycling facilities – be it architectural or product design - needs to support ease of use need of occupants via equivalently well-designed visual differences and usability features. The lack of support for recognizing the function or for effectively interacting and using the facilities may be conducive of poor recycling and waste management practices.

7.3.4.2. Hygiene

Occupant interviews reveal how the recycling receptacles' lack of support for hygiene needs may act as a deterrent for recycling behaviours and may be an impetus to cease recycling despite strong intentions to recycle. One of the residents arrives to the sustainable accommodation with well-developed recycling habits, however, faces the recycle bins that easily get dirty during use. The resident invests considerable effort in trying to repeatedly clean the bins, only to eventually give up on recycling altogether in avoidance of having to continuously wash the “disgusting” bins (sub-section “Hygiene – cleanliness of the bins” of 4.3.2.4 on pg. 124).

The survey corroborates the inferences of the student interviews and shows that the perceived hygiene of the waste bins correlates significantly with the self-reported frequency and correctness of recycling behaviours (Figure 51.). The cleaner residents perceive recycling is afforded by the waste bins the more frequent and the more correct their recycling practices. In contrast, the dirtier the bins are perceived, the less frequent and the less correct residents recycling practices. A total of 16.7% residents report not to recycle because the bins are “messy”.

Given that the design of the receptacles is not part of architects’ agenda, just as in case of ease of use, photographic data is used interpret the potential design intentions potentially related to the hygienic use of the bins. The photographic data produced by a participant (Figure 31.) demonstrates that the bins identified as unhygienic were indeed covered by traces of waste that probably stuck easily to surfaces around the openings. The reason for the bins to get dirty might be nested in their design. More specifically the bins in discussion have a small opening for refuse waste and a large opening for recyclable waste. Both openings expose curved surfaces with which waste may easily come in contact with when occupants try to dispose of it. Therefore, the final design and its use suggest that design time considerations might have been inappropriate to the actual hygienic use of the bins.

The qualitative and quantitative findings, together with the photographic data highlight the importance of design time considerations of hygienic use of the waste bins to stimulate recycling and to promote better and more frequent recycling practices. Especially so in scenarios where the waste receptacles are provided at scale in multi-occupancy residences - such as student accommodations - where hundreds or thousands of residents may face the same deterrent simultaneously. However, architectural design is less concerned, with waste bins in the accommodations. Designing the bins usually falls into the area of industrial product design while selecting, procuring and maintaining bins is likely to fully be in the control of the accommodation operators. Thus, the support for occupant need of cleanliness weighs both on product designers and operators if recycling practices are to be boosted in the student accommodations. While designers could aim to create receptacles that support hygienic use, operators assessment on how far real-life use of the waste receptacles is hygienic via well-conceived tests prior to procuring bins at scale for large, multi-occupancy residences, may be key for facilitating widespread recycling behaviour among occupants.

Overall, key considerations arising from the study of design satisfaction of hygienic use of the bins and its associations with recycling behaviours and practices in the communal areas of sustainable student accommodations are as follows:

- To prevent or reduce the perceived lack of hygiene of the bin use and potentially facilitate recycling in student accommodations it may be recommendable to design bin openings which are sufficiently large to ensure easy and hygienic discard of the waste, and to limit the contact surface around the openings to prevent waste adhering to it;
- Informing product designers and operators on hygiene as potential design driver of recycling behaviours and encouraging them to commission and integrate receptacles that meet occupant hygiene needs might be worthwhile to enable more frequent and correct recycling in sustainable student accommodations.

7.3.4.3. *Comfort*

Student interviews reveal that comfort, more specifically the perceived proximity of the waste bins, might play an important part in supporting or undermining recycling practices. In cases when residents perceive the recycle bins distant from their actual indoor locations, they report that taking out the recyclable waste is uncomfortable and are less likely to recycle. In contrast, when residents perceive the waste bins close enough to their flats to take comfortably take out the separated waste, they are likely to report regular practice of recycling (sub-section “Comfort–proximity of the bins” of 4.3.2.4 on pg.122).

However, closer examination of the same issue suggests that the comfort of recycling in terms of proximity of the bins seems to be a highly elastic and subjective concept. The distance of kitchen bins from the student rooms can be safely assumed to be shorter than the distance of outside bins from the kitchens. Still, some residents find the kitchen bins uncomfortably distant to reach from the room while other participants do not mind leaving the flat to take the separated waste to receptacles located several floors away. It is therefore very likely that other factors than the physical distance of residents from the receptacles might be contributing to recycling actions. It could well be that some residents find it more uncomfortable to leave their private sphere, in this case their rooms, to discard of recyclable waste such as paper or tin can.

The above assumption is partially supported by residents’ recounts in a number of ways. One is that residents who reported recycling as uncomfortable, were describing the scenario of leaving the room - their private space, to use the recycle bins from the kitchens - which is a shared space , while residents who were comfortable with recycling were describing the scenario of leaving the kitchen - the shared space, to take the separated waste outside the flat - which is also a shared space. Another support for the same assumption is that even though some residents do acknowledge the closeness of the kitchen bins from their rooms, they still report lack of recycling since they only have recycling bins in the kitchen but not in their rooms. Although they do not

explicitly mention the issue of leaving their private space or its potential impact on recycling, the fact that they acknowledge the short distance between the kitchen and their room in the context of recycling but do not practice recycling in the room can be considered a potential support for the assumption that the real issue is leaving the private space rather than the distance of the bins from the actual location of residents in the accommodation. In the very same scenario, since leaving the room right after the waste is generated seems to feel uncomfortable for residents, just as accumulating recyclable waste in the rooms until it is taken out in the kitchen, residents seem to discard the recyclable waste in the only bin in their rooms which is provided for general waste. Further support for the above assumptions are drawn from the results of the quantitative study where the group comparison of recycling frequencies show that students who reside in rooms equipped with recycle bins recycle significantly more often in their rooms than those without a recycle bin in their rooms (Table 23. ANOVA test for Recycling frequency by presence of bins in rooms.). Although the above findings provide some support for the assumption of interest further research is needed to better understand which factor, proximity or privacy may be related to recycling in student rooms.

Architects report marking the location of waste receptacles while verifying that the distances of the receptacles from different areas of the accommodation are according to requirements, in this case BREEAM (MH Arch in “6.3.10 Sustainable waste management and recycling”). Nevertheless, the distance of the recycle bins from student rooms is not reported to be examined in a way that supports resident comfort needs. What might be considered proximal by designers, can be experienced as distant and uncomfortable by the occupants using the building. Furthermore, accommodating recycling bins in student rooms and ensuring that residents do not have to leave their private rooms to discard recyclable waste comfortably is not reported to be part of architects’ agenda.

However, the current data suggests that supporting occupant comfort, both in terms of having the bins in occupant perceived proximity and in terms of not needing to leave the private space to recycle, may be significant in attaining higher recycling rates. It also suggests that further studies might be needed in better understanding which factor whether the proximity of bins or the availability of recycling facilities in the private space might be more conducive of recycling practices in student accommodations. Nevertheless, considering only the current investigation, a simple guideline might already be available and viable, that is: equip accommodation rooms with recycling facilities, to likely boost occupant comfort and recycling in the hundreds of thousands student accommodation rooms.

7.3.4.4. *Conclusion*

Out of the needs of comfort, ease of use and hygiene - significantly related to prevalence of recycling behaviours - architects only discuss supporting occupant comfort in the design of waste management systems of sustainable accommodations. Therefore, the present study advocates that integrating ease of use and hygiene need supportive aspects in the design of the waste management facilities could significantly improve recycling in sustainable student accommodations. Furthermore, the waste management related comfort needs architects provision for by design seems not to be nuanced enough to fully support the type of comfort need residents would necessitate to recycle. Thus, better understanding and supporting occupant comfort by design could potentially generate more prevalent recycling practices in student accommodations.

Furthermore, the study also reveals that recycling is a process touching upon several spaces of the accommodation from student rooms to kitchens and dining areas to the waste collection points outside of student flats sometimes outside of the building. Therefore, recycling behaviour has to be supported throughout the whole process by the design of the facilities in order to achieve a desirable final outcome. Ensuring easy to use and clean recycling facilities in the kitchens might not be enough if the rooms do not accommodate recycling. Similarly, well-designed indoor recycling facilities may not reach their overall goal if waste separation does not happen at the outdoor recycling facilities. Thus, understanding the most important stages of recycling and supporting recycling at each stage in the design might better promote recycling in sustainable student accommodations.

It is also apparent that the design of the waste bins as integrated design objects in the built environment is not part of architects' agenda. Architects might go as far as indicating the designated location of the waste bins on their plans, however they do not get involved in the actual design of bins where the features potentially supporting ease of use and/or cleanliness are decided upon.

Additionally, the responsibility regarding the design of the recycling receptacles is often in the realm of object designers while the commissioning of bin and their location reverts to the operators of the accommodations, since they are the ones who decide, commission, locate, maintain and occasionally replace these objects. Therefore, to boost recycling, the effort of several actors involved in the design, purchase and maintenance of recycling facilities needs to be synchronized and consistent in their support of occupant needs.

7.4. Potentially mismatched affordances

This chapter discussed how far occupant perceptions on the ways the sustainable accommodation sways their environmentally significant behaviours is being anticipated or matched by architects' intentions to support sustainable occupant behaviour. However, some design features the architects utilized as promoters of sustainable attitudes and behaviours captured in Chapter 6, remain unmentioned by the occupants during the interviews. Since the occupant interviews preceded the architect interviews, the available occupant data cannot explain why those features went unnoticed by occupants. Nevertheless, a reflection about the underlying reasons for these potential mismatches can be attempted based on the circumstantial data at hand.

In Crome Court, for instance, despite the architect intention to signal the sustainable character of the building via a sizeable green wall on one façade, occupant accounts remained silent of this feature. Since the researcher had already noticed the green wall on an initial site visit well-before any occupant interviews took place, was aware of its presence and presumed the design intention behind it. However, seeing that participants do not mention this feature at all, the researcher posed direct questions on it, which revealed that residents were unaware of the existence of the green wall. Further prompts revealed, that participants never used the entrance where the green wall was, instead they accessed the building from another side, partially explaining the mismatch.

Similarly, in Daniel Defoe Hall, the architect installed suspended bicycles as exterior decorative features evocative of sustainability. The same architect went further and designed a courtyard which accommodated a hub for foldable bicycle rental, a thematic shop selling and repairing bicycles, and a thematic coffee shop to lure residents but also visitors into the area, and to advertise and initiate the sustainable transportation mode of cycling. Despite the architect's intention and their stated belief that this hub is a building feature that does not only increase awareness but also encourages sustainable cycling behaviour, none of the interviewed residents mentioned any of these features.

There might be several explanations for these apparently flagrant misalignments. First, it was observed during site visits, that the passageway where the decorative suspended bicycles had been placed, was little frequented by residents or visitors, and the main entrance was on the other side of the building. This may partially explain why occupants did not mention the suspended bikes. Furthermore, based on the discussions with the accommodation providers, the bicycle repair shop and the cafe were never completed. It could be, that without those facilities, the hub remained less appealing and inviting for both residents and neighbours alike. However, this means that a misalignment between design intention and occupant response cannot be

claimed since completing all features of the building design was outside of architect agency. Finally, the architect interview contains passages of already solved challenges with the bike rental scheme operating in Daniel Defoe Hall. One of those challenges was about a small number of bikes being misappropriated. This suggests the Sherlockian conclusion that the bike rental scheme was being used by residents, despite occupants not discussing it in the interviews. Therefore, a complete misalignment between the bike rental facility related design intention and occupant sustainable transportation choice can be cautiously dismissed.

A further potentially plausible explanation for all the above apparent misalignments could be that when occupants are asked about the building in general and the various elements of the building supporting or interfering with sustainable behaviours and sustainable use, they mostly speak of interior design features. They talk about how they use their rooms, the communal areas, how they use the lights, how they heat or ventilate their rooms, how they use water for various purposes or how they manage waste. In contrast, they rarely talk about the exterior, the envelope of the building or the areas and facilities surrounding the building.

The final apparent misalignment between design intention and occupant recounts this section discusses, is presented by the exposed CLT wall extract in one of the corridors of Crome Court. The intention of the architect was to signal the sustainability commitment of the building by showcasing the structure of the walls otherwise invisible to residents, accompanied by a short text detailing the sustainable materials and features used in the building. Despite these efforts, none of the interviewed residents mention reading the description or indeed noticing the wall extract. When the architect was asked what they thought could be the reason behind that, they recognized that despite the studio's laudable collaborative approach to design, more information and collaboration would have been needed to make the design feature more noticeable. Additionally, it became apparent during the walk-through of the building that, the wall extract was placed in an area less frequented by students, next to the staircase which based on anecdotal evidence was far less popular than the elevators. Therefore, besides consolidating knowledge on how to make design features more noticeable and digestible for the student population, understanding how residents would use the building, might be highly desirable to make design features showcasing sustainability noticed.

While it would be fascinating to understand how and more importantly why some design features intended to support sustainable behaviours remained unmentioned and potentially unnoticed by occupants, based on the evidence collected in the present thesis, the researcher only ventures to make the above guesses. Nevertheless, a future study that collects occupant feedback based on

known architect intentions, would be an excellent complement to the investigations incorporated in this thesis, and would allow a better-founded explanation of the apparent misalignments.

7.5. Conclusion of the comparative analysis and synthesis

The comparison of Occupant and Architect FNB tables reveals that where architectural intentions are aimed at supporting occupant needs and sustainable occupant behaviours, sustainable behaviour may be more prevalent since occupants perceive the accommodations afford sustainable use via well-supported occupant needs. However, where architectural intentions to support occupant needs and sustainable behaviours are missing, sustainability of occupant use likely remains unencouraged or even deterred. Hence, the first major opportunity for improvement in sustainable accommodation design is the perseverance of architect intention to support occupant needs and sustainable behaviours by design. However, while perseverant architect intention may be a necessary condition to evolve behavioural sustainability of sustainable accommodations, it may not be enough. The studies supporting this synthesis show that architectural intentions may be curtailed by architects limit of agency over “their” projects, since multiple external circumstances such as client requirements, budget constraints, or even sustainability certification processes, may limit design intentions and decisions. Therefore, this thesis argues that obstacles and curtailments to existing architectural intentions to support occupant needs and promote sustainable behaviours, may need to be annulled via policy recognition of occupant need support in promoting sustainable use in architecture.

The deeper analysis of the overlaps of the Occupant and Architect FNB tables further reveals additional, granular opportunities for improving sustainable occupant behaviour. These opportunities are concerned with the detailed understanding of occupant needs in the context of a specific behaviour and support for those needs via design. More specifically it was found that there may be differences in nuances to how architects consider the occupant needs and behaviours should be supported by design, and occupant-expressed need support conducive of sustainable use. The thesis argues that using the FNB tables and the methodology of building and comparing FNB tables may provide architecture with a tool to identify the differences in nuances, and consequently integrate into practice an occupant perception-matching understanding of occupant need support potentially aiding behavioural sustainability.

By identifying the above opportunities for improvement, the present chapter achieves its major goal to answer the third research question of this Thesis. The following Chapter will discuss how the findings of the investigations integrate with the current literature, and what are the further

questions and paths for further investigation that were found during the quest to answer the questions of this thesis.

8. Discussion and conclusion

This chapter starts with the restatement of the research aim and the theoretical stance of the thesis. It further reiterates on the research questions and shows how the research questions have been answered and provides the summary of the results. Additionally, it presents how the study supports, complements or contradicts the existing knowledge base and highlights its contributions to research, methodology and practice. The chapter then considers the strengths and limitations of the thesis. Finally, recommendations for future work are presented before the concluding thoughts.

8.1. Aim

The present study developed insight on how architecture, materialized in sustainable buildings, might shape environmentally relevant occupant behaviours and building interactions, with the overall aim to fill the knowledge gap and feed information back to architecture to further the support of sustainable occupant behaviours by sustainable building design.

Knowledge was developed by relying on the design-familiar concept of Perceived Affordances (Norman, 2002) adopted into the context of sustainable buildings and sustainable behaviours. The concept of Perceived Affordance suggests that sustainable buildings may support sustainable occupant behaviours and building interactions when occupant perceptions on how the sustainable building affords sustainable behaviour i.e. “perceived affordances”, match the architects’ design intentions to afford sustainable behaviour by building design i.e. “designed affordances”. Hence, the study develops insight on occupants’ perceptions on how the sustainable buildings afford sustainable behaviours, explores architects’ intentions to afford sustainable behaviour via design, and finally compares occupants’ perceptions with architects’ intentions, the “perceived affordance” with the “designed affordance”, to identify matches and mismatches between the two.

8.2. Answering the research questions

The initial questions of the research were answered as follows:

8.2.1. Research Question 1

How do occupants of sustainable student accommodations perceive the building affords environmentally sustainable behaviours and building interactions?

The Occupant Interview Study generated the data-grounded new theoretical understanding that occupants perceive that sustainable buildings afford sustainable behaviour when their needs are

well-supported by the design features. The study found that in cases when occupant needs such as *comfort, control, privacy, ease of use* and *hygiene* are perceived to be supported by the design features of the sustainable building, occupant behaviours, such as *light use, heating, ventilation, waste management* and *recycling* may be more environment friendly. In contrast, when occupant needs are perceived by occupants to be missed or not supported well-enough by the design features of the sustainable building, their behaviours appear to be less environment friendly. The findings compiled into a newly developed Feature-Need-Behaviour table makes the relationship between building features, occupant needs and occupant behaviours easy to follow. Additionally, the most prevalent relationship from the FNB table are tested and corroborated quantitatively through the Occupant Survey Study further highlighting the statistically significant relationships between the design supported needs and the sustainability of behaviours.

8.2.2. Research Question 2

How do architects of sustainable student accommodations intend to support sustainable occupant behaviours and building interactions by their designs?

The Architect Interview Study reveals architects' associations of design feature integrated into sustainable accommodations with intentions to support a broad range of environmentally sustainable occupant behaviours and building interactions. *Cycling, taking the stairs, reducing energy use, or preventing littering* are a few to mention.

Besides the intention to design the building in a way that affords the sustainable behaviours, architects also intend to raise awareness by various design elements integrated into the sustainable building to promote positive, sustainable attitudes and eventually facilitate sustainable behaviours.

Furthermore, the findings also reveal that although not always connected to sustainable behaviours, architects do intend to support numerous occupant needs. The most prevalent occupant needs design features intend to support according to this study are *recognisability, information and feedback, availability, attractiveness, ease of use, comfort and control*.

Additionally, it was found that architects do not always have full agency over the design but must comply with other forces, such as client requirements or safety procedures. In those cases, although architects have the intentions to support occupant needs, their intentions might be "censored" in the final design.

Finally, the study develops an architect intention-based Feature-Need-Behaviour table with a structure identical to the FNB table based on occupant data, making the data sets comparable.

8.2.3. Research Question 3

How do occupant perceptions compare with architect intentions and what are the good practices and the opportunities to better afford environmentally sustainable occupant behaviour by the design of sustainable student accommodations?

The comparison of occupant and architect data, facilitated by the newly developed FNB tables, allowed the identification of gaps and overlaps between the most prevalent needs occupants mention to be vital to be supported by design features in order to use the building in a sustainable manner and how the support of those needs is present in architects' intentions. The juxtaposed occupant and architect data based FNB tables show that while the needs of *comfort, control and ease of use* are present in architects' accounts, *privacy* and *hygiene* are missing from architects' agenda.

Furthermore, when architect intentions include occupant needs, occupant perceptions seem to be more balanced and more on the positive side with potentially more sustainable behaviours. On the other hand, in cases when architect intentions are oblivious of occupant needs the occupant perceptions seem more likely to be skewed towards a more negative spectrum, potentially leading to less sustainable occupant actions. This means that including the most prevalent occupant expressed needs on architects' agenda may be key to the behavioural sustainability of sustainable accommodations.

Nevertheless, simply including the needs on architects' agenda might not always be enough to promote sustainable behaviours. Occupants' negative perceptions on the need support in overlapping areas such as *comfort* or *control*, indicates instances when architects' intentions, although present, do not match with occupant's perceptions calling for a deeper understanding of those occupant needs by architects.

Additionally, the cases where the limiters of architects' agency "censor" architect intentions to support occupant needs and occupants' perceptions echo the restricted support of needs, indicate that architect's agency to support needs should be extended. This agency extension could be facilitated by policy patronage of need support or by including need support in industry-wide certification schemes such as BREEAM that may incentivize developments to be more considerate of occupant needs.

To summarize, the overlaps between the occupant FNB tables and architect FNB tables highlight areas where good architectural practices exist, and improvements may be a matter of fine-tuning architectural knowledge or extending architectural agency. Conversely, the gaps between the tables show areas where seems to be a dire necessity for architectural consideration and good support of occupant needs and a significant, but as of yet unexplored, architectural potential for improving the sustainability of occupant behaviour patterns.

8.3. Contribution to knowledge, methodology and practice

8.3.1. Contribution to knowledge

8.3.1.1. *Architecture's influence on human life and sustainable behaviour*

As mentioned in Section 2.2 of the Literature review chapter, there are many studies on how architecture might shape a multitude of behaviours, starting from health-related behaviours, to wayfinding, from social interactions to crime prevention (Crowe, 2000; Gehl, 2009; Kopec, 2012; Sternberg, 2009). Nevertheless, there is very scant research on how architecture might shape environmentally sustainable behaviours. The present thesis reduces the knowledge gap and suggests that sustainable behaviour supportive architecture is also need supportive architecture. In other words, sustainable architecture supports sustainable occupant behaviours when occupants perceive their needs are well supported by the building and its features. Conversely, the thesis also argues that architecture that is oblivious to support or fails to adequately support occupants' expressed needs, might lead to unsustainable behaviours. This potential dual influence of architecture on sustainable behaviour resonates well with earlier architectural studies which suggested that while architecture has the potential to enhance human life, it may also lessen it.

8.3.1.2. *Sustainable buildings promoting sustainable behaviour*

The thesis adds to the scant and often contradictory building science and social science studies that investigate whether sustainable buildings promote sustainable behaviours (Azizi & Wilkinson, 2015; Berry et al., 2014; Clarke, 2013; Kato et al., 2010; Khashe et al., 2015; Pilkington et al., 2011; Williams & Dair, 2007; Wu et al., 2017). The present findings suggest that the answer is more nuanced and less dichotomous, and sustainable buildings might support sustainable behaviours when occupant needs are well-supported by the sustainable building design.

Furthermore, since the above-mentioned studies are mainly investigating more abstract characteristics of sustainable buildings such as occupant knowledge on the certification of the building, the present study stands out by placing the physical environment, more specifically the physical design features of the sustainable building into the heart of the investigation. The closest

study found was performed by Williams (Williams et al, 2010) who quantitatively investigated the relationships between the physical, built environment and sustainable behaviours, and concluded that while the presence of some features in the built environment might be related to certain sustainable behaviours, others less so.

The present research complements Williams's results. On one hand, it complements it by concluding that there seem to be statistically significant relationships between the physical features of the building and sustainable occupant behaviours. However, the present findings go beyond purely identifying relationships between the existence of features and sustainability of behaviours (Williams et al, 2010), and finds that the relationship seems to be shaped by the perceived support of occupant needs. More specifically, when occupants perceive their needs are supported by design, they are more likely to exhibit sustainable behaviours. Furthermore, Williams concludes the built environment has limited potential in facilitating sustainable behaviours and identifies behaviours that can (energy and water use) and cannot (recycling) be facilitated by the physical environment and its features (Williams et al, 2010). Nevertheless, the present thesis arrives to a rather different conclusion and argues that there might not be a restriction on the type of sustainable behaviours the built environment and its features may facilitate but the successful support of the sustainable behaviour could be dependent on the need supportive quality of the design features in the built environment. In other words, it is not that some sustainable behaviours can be supported by design features of the built environment while others cannot, but it is the need supportive quality of the design that may sway whether the behaviour will be more, or less sustainable.

8.3.1.3. Design for Sustainable Behaviour

The idea that certain qualities of an artefact may sway sustainable user behaviour has been extensively explored in Design science as shown in Section 2.4. The field concentrates valuable knowledge on how people use various artefacts and offers strategies to support sustainable behaviours by the design of those artefacts. However, these studies mainly focus on independent objects and specific behaviour they shape rather than multiple, potentially interrelated objects coexisting in a building and on their concerted effect on sustainable behaviours. Furthermore, these studies also do not include characteristics specific to architecture, such as the orientation, light levels, thermal environment, or floor level of the building and how those may shape sustainable behaviours.

Thus, the present study can be considered as a contribution to the field by adding the building scale on its palette and showing how the elements and features integrated in the sustainable

buildings shape sustainable behaviour. It finds that design features such as windows, although may be considered as single objects that allow daylight in rooms, together with other design features such as shading devices, floor level, furniture arrangement, room wall colours, staggered design influencing shading from adjacent buildings, or pedestrian path distances to windows may have a concerted effect on perceived need satisfaction and sustainable light use. Hence it underlines that when sustainable behaviour is desired in a sustainable building, architects may have to consider multiple design features and their relationship, and how those together may support occupants in using the building sustainably.

The present findings partially also resonate with a core idea of Design for Behaviour Change that sustainable user behaviours could be shaped by strategies ranging from enabling to restricting actions and by making the actions easy or difficult for the user (Niedderer et al., 2014). While the present thesis agrees that making sustainable behaviour easy and enabling use is supportive of sustainable building use, it rejects the view that by making use difficult and restricting action could also be sustainable behaviour supportive. In fact, this thesis suggests that making use difficult and limiting user control, may be a good invitation if not a perfect recipe for unsustainable behaviours and building interactions. The present thesis shows that in cases when occupants of sustainable accommodations find use difficult, or lack control over the features of their environment, they try to regain that by not using those features or not using those in an intended, sustainable way, hence potentially undermining the sustainability of the building. Hence restricting control, or making use difficult, although it could work with other types of behaviours or on object design scale, it seems to work against rather than for sustainable behaviours in the context of sustainable buildings.

The revelation that need supportive design is likely environmentally behaviourally supportive in the context of sustainable accommodations is an important finding for sustainable architecture and for architects who wish to support sustainable building use by their designs. This finding could not have been deduced from simply exploring the design strategies relevant for sustainable object use. Therefore, the present study provides understanding but also a way of thinking for architects who wish to better support sustainable occupant behaviour. The thinking pattern of “supporting occupant needs by design to support sustainable behaviours” may even be considered as an extension of the “Architectural lens” design patterns deck of Dan Lockton’s “Design With Intent Toolkit” (Lockton, 2013).

8.3.1.4. Occupant Needs and Environmentally Significant Behaviour

Section 2.5 discussed understanding of environmentally significant behaviours and theories explaining ESB. The sections below show how the present thesis contributes to this area of knowledge and what theoretical and empirical contributions it makes, including those to the Design-adopted form of Theory of Affordances.

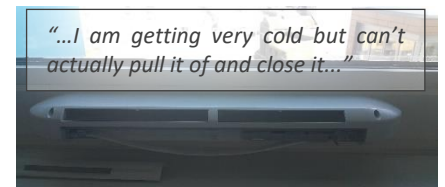
It was shown how the literature of sustainable behaviours identifies moderate resource use actions as curtailment behaviours associated with a significant decrease on occupant comfort and quality of life. However, the present thesis, based on its novel and original findings that supporting occupants needs for *comfort, control, privacy, ease of use and hygiene* by design is not working against sustainability but instead might be a prerequisite for enabling and supporting sustainable use of the sustainable accommodations, comes to a differing conclusion. The thesis is hence sceptical about the viability of curtailment actions when comfort and other needs are diminished and argues for an alternative paradigm where sustainable behaviours are facilitated via strong design support for occupant needs.

A glimpse on the inter-twined nature of occupant needs to be supported in order to promote more sustainable occupant behaviour in sustainable student accommodations is also provided in the “Comparative Analysis and Synthesis” chapter of this thesis. For instance, it argues that lack of design support for privacy need in private spaces, such as student rooms, may thwart the best design intentions meant to support visual comfort needs, eventually leading to increased and as such unsustainable daytime artificial light use.

While satisfaction of occupant comfort needs have been extensively investigated in relation to perceived indoor environmental qualities (Al horr et al., 2016; Frontczak & Wargocki, 2011; Huang et al., 2012), their investigation in relation to sustainability of occupant behaviour constitutes uncharted territory the present study entered. In addition, the research quantified the explanatory power of need satisfaction by design on the variance of environmentally relevant occupant behaviour, which to the knowledge of the author was not quantified before.



Figure 105. Trickle vents.



8.3.1.5. *Needs and Affordance Theory in sustainable architecture*

The findings of the present thesis resonate with the *Perceived Affordances* concept developed by Don Norman, suggesting that an artefact - in this case the sustainable building with its features, may afford an action on it - in this case sustainable behaviours, if the occupant perceives the qualities of the artefact enabling that action and if the user is able and capable of performing the action. Conversely, actions may not be afforded by artefacts when the action possible on the object is not perceived, or when the capabilities and abilities of the user do not allow the user to perform the action. For instance, the present study finds that trickle vents in the accommodations do not always afford sustainable ventilation practices since these are hidden from view and therefore cannot be perceived by the occupants, occupants do not recognize its function, or they recognize its function but do not understand how to use it. (See Figure 105.)

Nevertheless, the present research reveals that there is more to affordances than just perceiving the qualities of the feature that enables the intended use and the ability or capability to perform the intended action on it. It suggests, that whether a building feature affords or not the intended sustainable use, might also be shaped by how occupants perceive their needs are supported by the design features. For example, it may not be enough for occupants to perceive the daylight affording qualities of the window of the rooms and have the ability and capability to use the window in a way that allows daylight in the room, but the window also has to be perceived as affording support of visual privacy. Otherwise occupants likely resort to using the window in a less daylight supporting way by shutting blackout blinds and turning on artificial lights. Hence, in this case, the window does not afford visual privacy and therefore the same feature does not afford sustainable daylight use for occupants. Conversely, the windows better afford sustainable daylight use when visual privacy is perceived to be supported by the same feature. As such, the thesis argues that besides the perceivability of affordances and the ability and capability of the occupant, the perceived satisfaction of needs, such as visual privacy, might also be pivotal for the architectural design to afford sustainable use. Hence the sustainable behaviour affordances of sustainable accommodations also incorporate perceived support of occupant needs.

The identification of occupant need support as sustainable behaviour affordances of sustainable accommodations leads the thesis to discuss the topic under the newly constructed, data-grounded Feature-Need-Behaviour framework. Additionally, the FNB framework better reflects the occupant way of thinking, while phrasing the issue in terms of affordances is more representative of designers, and the thesis argues that approaching the matter primarily from the occupant perspective could lead to better, more sustainable behaviour supportive design. Hence,

emphasising on the need support of the features and phrasing it in the framework of FNB seems more representative of sustainable building feature use and sustainable occupant behaviours.

Furthermore, Perceived Affordances in their usual form are user perceptions of how to use a specific artefact. Hence, they represent behaviours the user thinks they can perform directly with the specific artefact, and eventually may perform with the same artefact. There is a “one-to-one” relationship between the artefact and user. However, the present study finds that the case of Perceived Affordances in the context of sustainable buildings and sustainable behaviours is more complex than the case of Perceived Affordances in individual artefact use. First, there may be multiple artefacts involved in the relationship rather than one specific artefact. Occupants of the sustainable buildings perceive their environment as composed of multiple design features, that together may have affordances. Hence there is a “many-to-one” relationship between features and the occupant. For instance, in the case of windows, the window itself may be a core design feature or artefact that allows natural light into the room, however how far it is perceived to support occupant daylight comfort need or privacy need may be influenced by multiple other design features of the building such as furniture arrangement in the room, colour of the interior walls, shading devices, floor level, shading from adjacent buildings or proximity of walking paths, to name but a few. These together are perceived to afford sustainable light use.

Additionally, the interaction or behaviour afforded by the design features may occur with design features potentially different from the ones that are engaged with supporting an occupant need. For instance, where the room windows are not supportive of comfort of daylight, occupants do not turn to windows for more natural light but turn on artificial lights.

Conceptually, reducing the plethora of design features that afford sustainable behaviour to the concept of “feature clusters” and labelling support of occupant needs as “affordances” would still lead back to the same conceptual representation as in case of perceived affordances of an artefact. However, in the study of sustainable accommodations and sustainable occupant behaviour the more complex representation and the FNB table allows a better understanding of the topic.

In terms of empirical contribution, the present thesis also extends earlier empirical knowledge generated by studies adopting the conceptual framework of Perceived Affordances (Norman, 2002) in investigations of sustainable buildings. Wu, using a similar affordance based theoretical stance, investigated how sustainable buildings act as communication channels of sustainable messages with the potential effect to promote sustainable attitudes and eventually facilitate pro-

environmental behaviours (Wu, 2016). Their study finds that green buildings may afford increased awareness on the sustainability of the building. However, their results did not have the opportunity to shed light on whether or how the same buildings afford sustainable occupant behaviours. The present study complements this understanding and suggests that sustainable accommodations afford sustainable occupant behaviours when occupants perceive their needs are catered for by the design features of the building. Additionally, the present study juxtaposed occupant perceptions with architect intentions, matching Wu's recommendations for future work, who, based on Don Norman's argument, acknowledged the need for understanding how architects encode sustainable ideas in their design and how occupants decode those ideas and perceive the design affords sustainable use.

8.3.1.6. Not so miss-matched affordances

The present research complements but also contradicts earlier studies suggesting that architectural failures may likely be responsible for the sustainable buildings not being used in an expected, sustainable way, also called the mismatch between the expected or designed and actual or real use. More specifically, as shown in Section 2.6, it is often implied that the reason behind the infamous mismatch is that architects may not know or care about how occupants use or may want to use the buildings. As a response, occupants often readjust the features of their environment, and proceed to using the building according to their motives and desires, which may result in unsustainable use.

Although the above-mentioned studies might bear some truth with them, none of them considers architects intentions. The fact that occupants are uncomfortable with the use of certain building features and as a consequence they readjust those to their needs and wants, is knowledge validly generated from occupant data and actual building use. However, making assumptions on architects' knowledge and understanding of how occupants use and want to use the building and hypothesising that architects might not have the knowledge or the intention to support that by their design, without collecting architect data is beyond what can be concluded based on occupant data solely.

The present study complements the above-mentioned studies by bringing first hand evidence on architects' intentions in promoting sustainable occupant behaviours by design and matches that against the occupant's perceptions on how those behaviours are actually supported. The findings, however, contradict earlier studies by showing that although there are opportunities for improvement, architects overall understand occupant needs and wants and also intend and often manage to successfully support the intended sustainable behaviour. Hence, "the architect" might

not be that unknowledgeable and indifferent towards occupant needs and might not always fail in supporting the intended, sustainable behaviour as earlier studies may have assumed.

The present investigations show that architects do cater for various occupant needs such as *recognisability, information and feedback, availability, attractiveness, ease of use, comfort and control*, and design for specific sustainable occupant behaviours, as presented in Chapter 6, which is a major contribution to knowledge. Furthermore, the comparison of architect's intentions and occupants' perceptions in Chapter 7. shows good overlaps in the area of satisfying *comfort* and *control* need which are key occupant needs related to sustainable use of the building.

Section 2.6.4 discussed how architects are believed to conceptualise occupants as Passive agents. The architect data gathered and analysed in Chapter 6. begs to differ. It shows that designers do consider a wide range of occupant behaviours during the design of sustainable accommodations. This implies that the occupants are considered by architects as acting and interacting agents rather than passive agents.

The fact that *comfort and control* seem to be relatively well-supported by architects and often linked to sustainable occupant behaviours which are also intended to be supported by architects, suggest that the gap between the designed and actual comfort and the designed and actual comfort related behaviour is not so yawning as Section 2.6.3 may suggest. While the study supports the assumption that the gap between designed and actual comfort can lead to unsustainable occupant behaviours, it argues that the mismatch is not as big as it was suggested. Furthermore, the study also brings evidence that the *comfort* or *control* related gap, where it exists, is not necessarily caused by faulty architectural decisions. It has been found that architects' agency over their designs has its limits, and it is not that architects do not understand or intend to support the right comfort and control needs but they cannot support those to their best knowledge due to constraints such as client demands. Hence, it is suggested that in those cases the gap between the architect designed and occupant perceived comfort to be rephrased as the gap between the client required and occupant perceived comfort.

While the above may absolve architects from the believe that they do not intend to support occupant comfort, the study also found gaps between architectural intentions and occupant perceptions on the support of other prevalent occupant needs such as *privacy* and *hygiene*. More correctly, these needs were completely missing from architect's agenda. While this is a definite shortcoming in design that aims to be supportive of sustainable behaviour, it would be unreasonable to say that architects do not intend to support these needs. It is more that

architects do not necessarily know about these occupant needs, and as such the study argues that by integrating this knowledge on architect's agenda and ensuring these are understood and well supported by the architects in their designs could significantly improve the behavioural sustainability of sustainable accommodations.

The present study also complements earlier studies mentioned in Section 2.6.2, with its findings related to *ease of use*. Earlier studies suggest that the mismatch between architects' intentions and occupant's perception may be due to the increased complexity of designs that occupants do not comprehend. The present research corrects this assumption by evidencing a design concept also suggested by Don Norman: that complexity does not necessarily imply lack of comprehension, just as simplicity does not automatically mean that the users understand how to use certain features. In the present study, the case of the trickle vents on the room windows of two accommodations shows that although these objects look very simple and neat, they were reported to be difficult to recognize and unclear how to use. Hence, Norman's ideas that what is important is that the designers' conceptual model overlaps with the occupants' mental model via the system image which in this case is the trickle vent are further underlined by the study.

8.3.1.7. Architects engagement in sustainability practices

Finally, the findings complement knowledge in the area of architects' engagement with sustainability best practices such as adoption of sustainable design methods (Murtagh et al., 2016) or commitment to perform Post Occupancy Evaluations (Clark, 2015; Hay et al., 2017). It suggests that catering for occupant needs and aiming to promote certain sustainable occupant attitudes and behaviours is not a completely foreign concept to architects and it may be pursued to various lengths during the design of sustainable accommodations. This identifies a glimpse of hope for developing and integrating sustainable behaviour supportive design practices in sustainable architecture, complementarily to the integration of sustainable technologies.

8.3.2. Methodological contributions

The thesis puts forward the idea that the newly developed FNB tables and the process of developing the FNB tables may constitute a significant methodological contribution for the study of sustainable occupant behaviours in sustainable buildings. On one side, it allows capturing occupant perspectives of how the architectural space is perceived to sway sustainable behaviours which in the author's opinion is long due more extensive research. On the other hand, it allows capturing architectural intentions to support occupant needs and sustainable occupant-building interaction, area that is almost completely unresearched despite its importance in developing behaviourally sustainable buildings. Finally, since the FNB tables created from the

aforementioned datasets have identical structure, these permit a gap analysis between the two, that may identify shortcomings and best practices of supporting sustainable building use by design.

8.3.2.1. Applicability of the FNB Approach

Questions may arise on how far the newly developed FNB approach is applicable to understand sustainable behaviours in other building types, or other, not necessarily sustainability related occupant behaviours.

First, regarding its applicability in sustainable behaviour focused investigations in other building types, it can be theorized that occupants will have a set of needs in every building, needs that may or may not be well-supported by the building and its features. In the latter case, occupants may act to meet their needs and their actions may result in increased resource use or faulty waste management, making building use less sustainable. For instance, when office workers' need for glare related visual comfort are not fulfilled by the design features of the office building, they may act to reduce glare discomfort by closing off and using artificial lights; occupants of classrooms that overheat may resort to electrical devices to ventilate and cool air; in bedrooms where windows are perceived to permit excessive sightlines occupant may close off to restore privacy and then use artificial lights to restore visual comfort; and occupants of any building may mismanage waste more extensively when recycle facilities are designed to be in difficult to find location, complicated to use or ill-maintained. Similarly, studies on thermal comfort show occupants increasing energy use when their thermal comfort is diminished ([Cole et al., 2008](#); [Tweed et al., 2014](#); [Zapata-Lancaster & Tweed, 2017](#)). Hence, it is likely that the FNB approach is applicable to discovering and understanding numerous relationships between design features, occupant needs and resulting environmentally significant behaviour in various other building types than sustainable university accommodations.

Second, regarding the applicability of the FNB approach in investigations of occupant behaviours in general, it is likely that there are a multitude of occupant behaviours which are performed in different manners partially depending on how far the building and its integrated features meet occupant needs. For instance, in a library visitors may seek out quiet and adequately lit spaces to read, and avoid performing the same activity in noisy halls, confirming that the design features of a space are filtered through their needs for visually and auditorily comfortable environment and may lead to specific studying behaviours. A classroom that does not reduce road noise levels sufficiently to fulfil pupils' needs for acoustic comfort, students may get tired and distracted and may exhibit a decreased academic performance. Or in an airport, travellers may choose different

paths depending on how far the signpost are designed and placed in the space in a manner that fulfils traveller needs for ease of use in terms of noticing and interpreting the signs.

Comparably, results of earlier Environment – Behaviour research or some health behaviour research can also be conceptualized and interpreted in the FNB framework. For instance, the Cherulnik study (1993) that identified residents closing doors and acting less-socially due to diminished privacy caused by long and overcrowded corridors in student accommodations, allows clear identification of design features – single, long corridor with all rooms opening onto it, occupant need – privacy, and resulting socially relevant behaviour – closing doors. Similarly, the Bassett et. al (2013) conclusion that buildings constructed with centrally located, accessible and aesthetically pleasing staircases are likely conducive of more stair use generally considered healthy, also clearly allows identifying the design feature, the occupant needs and the resulting behaviour patterns.

In conclusion, this section argues that the FNB approach may be a suitable for investigations concerned with occupant behaviours in various building types.

8.3.3. Contribution to architectural practice

The main contribution of the thesis to architectural practice is that it informs architects on the importance of need supportive quality of building features in promoting sustainable occupant behaviours by the design of sustainable accommodations.

The newly developed occupant data based Feature-Need-Behaviour table shows how design features might impact on occupant needs and on environmentally significant occupant behaviours. Since it shows relationships at a glance, architects of sustainable accommodations may use this table to think about design features in terms of potential impact on occupant's comfort and well-being and environmentally significant behaviour and to better consider the potential sustainability consequences of their designs.

The descriptive parts of the thesis on what are the nuances of occupant-expressed needs, and how those needs are perceived and interpreted by the space users may also be helpful to architects. It may help avoid potential mismatches between architectural conceptualisations of occupant needs and occupant expressed needs.

The statistical tests from this thesis allow grasping the range of improvement in terms of occupants' resource use and recycling achievable by well-supporting occupant needs via design. In a very practical scenario, this may help architects engaged in a budget allocation exercise to argue effectively for design support of specific occupant needs since those have a quantifiable

impact on resource intensity or on recycling and hence on operating costs of sustainable accommodations.

The comparison of architect FNB table with occupant FNB table is also informative in nature given it shows what are the needs and behaviours considered and successfully supported by architects of the studied cases, what are the needs which were although considered but not well supported and finally what are the needs which were not considered by the participating architects during the design. This could help architects identify good case scenarios and relate that to their practices and to identify cases when the intentions do not match occupants' perceptions and their design seeking to promote more sustainable occupant behaviours needs to be reconsidered.

Overall, the present work provides an original thinking pattern to architecture of sustainable accommodations to start tackling the question of sustainable occupant behaviour and to decrease significantly the in-use environmental impact of sustainable buildings.

8.4. Strengths and Limitations

The original and first-hand data gathered from a total of 17 sustainable accommodation blocks, the in-depth, face-to-face interviews with the site architects and numerous resident students, and the comprehensive survey with 222 occupants represent major strengths of the study. Additionally, the participation of four different sites across the UK, three in England (London, Manchester, Norwich) and one in Wales (Treforest), can also be regarded as a noteworthy success, and may be considered as a significant leap towards constructing a data set representative of the UK.

The mixed methodology, using both qualitative and quantitative approaches to understand how sustainable accommodations might shape sustainable behaviours, allow the complementariness of the dataset and as such increases the reliability of the results. Moreover, since the exploratory inferences generated from the occupant interview analysis have been supported by the ensuing occupant survey analysis, the reliability and the validity of the study is increased.

Finally, a major strength of the study lies within its multi-disciplinary nature, connecting dots between Social sciences, Design, Building science and Architecture. More specifically, it visits psychological models applicable to understanding sustainable behaviour, identifies design knowledge that builds on social science theories to promote sustainable behaviour and explores ways this knowledge fits into current state of the art of sustainability focused Building science and Architectural investigations.

Next to the above strengths, as every PhD, the present thesis also has its limitations.

The architect of one studied site could not be convinced to participate in the study. Nevertheless, since the data resulting from the all sites was analysed together this limitation is somewhat mitigated. Furthermore, the data provided by the participating architects is a good source of knowledge given that the interviews were in-depth and face-to-face, lasting between one hour and ninety minutes, while the professionals could recount instances of design solutions applied in the studied projects but also in other projects of the same building typology.

The results indicate relationships between the need supportive qualities of design features of sustainable accommodations and sustainability of occupant behaviour. Although these relationships have been tested quantitatively and yielded statistically significant correlations, correlations do not imply causations. Therefore, the relationships between the need supportive quality of design features and the sustainability of occupant behaviours should be treated as associations with potentially other elements and factors interfering that relationship such as personal views, beliefs or culture.

The initial intention of the researcher was to build a random occupant sample that allows generalization of the findings. Unfortunately, data protection regulation that universities and accommodation providers must adhere to made obtaining a full residents list impossible, preventing the researcher from building a random sample.

8.5. Recommendation for future research

The present thesis is a cross-disciplinary exploration that generated original findings on how architecture materialized in sustainable student accommodations might shape environmentally relevant occupant behaviours. Given the qualitative findings also performed well when tested quantitatively, the path taken may be worthwhile pursuing in future research as proposed here below:

- Extend the range of the investigated environmentally consequential occupant behaviours in sustainable student accommodations across the UK;
- Generalize the findings by constructing a UK representative sample of sustainable accommodations and participants;
- Assess the usability of the FNB table during design as an informative medium for architectural thinking to support sustainable occupant behaviours by design;
- Perform quasi-experiments that test the causality of the need supportive character of design features from sustainable accommodation over prevalence of sustainable occupant

behaviour. This may provide solid data to propose such changes in policy and/or sustainability certification methods (i.e. BREEAM, LEED, etc.) that recognize the sustainability benefits of need supportive design.

8.6. Personal reflections

The very first set of skills this PhD taught me, even before it started, was to independently develop high quality, relevant, and original research proposals, argue for their merit and secure grants which in this case were jointly provided by EPSRC and the Welsh School of Architecture.

During the PhD, I realized that a PhD and a pilgrimage are very much alike. Firstly, during a PhD, just like during a pilgrimage, one will find some of the things they expected to find but also things they did not expect at all. The many unexpected twists and turns can be challenging and often give the sense of being stuck, which in case of the research process can be in the literature review, in the methodology, or in the data gathering and analysis, to name but a few. Secondly, the day by day progress made during the PhD, like on a pilgrimage, is tiny little, which in turn can easily challenge one's motivation. Finally, similarly to a pilgrimage, during the PhD journey, alternative routes may become tempting to explore, however taking those might get the traveller lost. Therefore, it became clear that only by persevering, appreciating all and every minor progress and remaining focused will allow me to successfully complete this PhD.

Even with this frame of mind, the learning curve was rather steep. What helped me was my genuine passion to understand how architecture relates to our well-being and behaviour, and how it may help stir our society onto a more sustainable path. While, I had training and professional experience in architecture, and studied Environmental Psychology, the theories and empirical findings on human behaviours, the design paradigms concerned with ways of use, and the body of knowledge on evaluating building performance, all reviewed in the present thesis, were areas little explored to me, on which I have gained a much better understanding. Similarly, while I had experience with qualitative research in an academic setting, the research methodologies the research questions of this thesis led me to, were novel to me and I feel I achieved a good mastery of those during this PhD. In addition to qualitative methodologies this now includes quantitative methods employing statistical analysis, which I felt were incredibly useful in testing and adding weight to qualitative inferences.

Appropriating all the new knowledge while also making progress with the research requires hard work with almost no time to stop. However, real progress would not have been possible without developing the skill to stop and reflect critically on the work. While this might seem as an obvious

thing to do, the continuously looming deadlines and the urge to rush and do more work, specific for a PhD, might easily give the feeling that pausing, and reflecting is a waste of time. In reality, it might save time from work done in vain.

The dissemination of the findings provided further opportunities for academic and personal development. Presenting at conferences helped me gain good presentation and communication skills and allowed me to discover how enjoyable of an experience that was for me. Additionally, conferences provided an excellent platform for understanding where my research is situated in the context of other relevant works, and for getting a better insight on what is good but also what needs more work in my research.

In terms of what worked well in this PhD, performing the occupant study before the architect study was an inspired decision. It allowed a pristine understanding on occupant perspectives rather than being primed by architects' intention of how and what they think occupants should experience and do in the sustainable buildings. In the occupant study, it proved to be a good choice to perform the exploratory study first, given there was very little knowledge on the topic. Here, selecting CGT as main methodology was equally a good fit, since it allowed a gradual build-up of knowledge into a theoretical understanding that withstood the following quantitative tests, while proving flexible enough to support capturing architect perspectives.

I had some doubts about performing face-to-face interviews with architects since a questionnaire or an email interview felt as tempting alternatives due to their time effectiveness. Nevertheless, I feel I took the right decision to perform face-to-face interviews since these allowed building a good report with architects, and having a candid discussion, while giving the opportunity to prompt for topics of interest.

For a while, it remained unclear how the occupant and architect perspectives would ever become comparable given the very different points of view of the two actors on buildings in general and the studied accommodations in particular. Nevertheless, the newly developed FNB table worked remarkably well in reconciling the two perspectives.

On the other hand, it was unfortunate that despite several attempts, one of the architects did not respond to the invitation, leaving one of the four sites unrepresented. This could have been avoided by only selecting sites where the architect participation had been confirmed. While I would still perform the occupant study first followed by the architect study, I would try to ensure that architects of all selected sites are willing to participate in the study at a later stage.

Beyond the above, there are couple of further elements I may do differently in hindsight. During the occupant interview study, I invested time in exploring the social influences of environmentally significant behaviours. While the knowledge I gained is valuable and valid, building it slowed the progress on the core of this study which is the relationship of the physical environment and sustainable occupant behaviour. Similarly, during the architect interview studies, I devoted some time to discuss with accommodation providers and sustainability managers of the accommodations. While these discussions taught me a great deal of how the accommodations work and what sustainability focused programmes the accommodations run, this knowledge does not touch upon the design of sustainable accommodations and therefore I would probably better control the time invested. Finally, I would persist more on building a random sample for the occupant survey. Although, I was well aware of the value a random sample brings, it was unfortunately impossible to build one due to the inaccessibility of lists of residents.

There were a few significant challenges during this PhD. Attracting sites in the study was the first. While I identified 15 sites that hosted sustainable accommodations, only four were willing to participate. It could be that the topic was sensitive, since it was investigating how the sustainably certified accommodation was helping or hindering sustainable occupant behaviours, which may have seemed as a questioning of their sustainability and maybe as a risk to the sustainable reputation of university accommodations. Luckily, the participating sites did realize the value of the study and accommodated it.

Attracting architects also proved to be a challenge. While the high workload characteristic to the profession could serve as an explanation, the reluctance to open-up and talk not just about the successes but also about the pitfalls of past projects could be partly to blame. I wonder if legal liability issues steaming from the adversarial nature of construction industry contracts in the UK may also be a deterrent for architects to speak candidly.

Finally, the limited funding available for the PhD was just about enough for generating the original data and became a significant obstacle in disseminating findings at conferences. Although multiple abstracts generated interest for presentations at international conferences, the funding cap greatly limited the number of conferences I was able to attend and present at. While this is an obstacle commonly plaguing PhDs in the UK, I believe this topic deserves an open discussion.

Overall, I found this PhD challenging and exciting. The skills I learned during the journey and the continuous support and encouragement of my first advisor helped me overcome the challenges

and turn those into opportunities. Doing the PhD also taught me to appreciate the countless things discovered, which enriched me academically and personally.

8.7. Final remarks

Architecture has a strong potential in significantly affecting many aspects of human life and behaviour. Its potential has been confirmed in a wide range of fields from health to human performance, from safety to positive social interactions. However, environmentally sustainable occupant behaviour is an area where little knowledge has been generated to help architecture promote behavioural sustainability by design. The studies of this thesis propose a social science grounded investigation of environmentally relevant occupant behaviours in sustainable accommodations matched against architectural practice, with results framed in a manner that may be consumable for architecture aiming to enable and promote sustainable building-occupant interactions. While its findings are promising, they only begin to comprehend how architecture may further behavioural sustainability in sustainable buildings in general and sustainable accommodations in particular, to eventually provide accessible tools for architecture to support what is perhaps the most important endeavour of this generation: environmental sustainability on our one and only planet.

9. References

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10. Appendix

10.1. Occupant Interview Study – Ethical Approval

EC 1601.258

WELSH SCHOOL OF ARCHITECTURE ETHICS APPROVAL FORM FOR STAFF AND PHD/MPHIL PROJECTS		W/S3			
Tick one box:					
Title of project:		<input type="checkbox"/> STAFF	<input checked="" type="checkbox"/> PHD/MPHIL		
The Experience and Meaning of Moving into and Living in Energy Efficient Student Accommodations					
Name of researcher(s):		Adrienn Rokosni			
Name of principal investigator:		Professor Wouter Poortinga			
Contact e-mail address:		RokosniA@cardiff.ac.uk			
Date:		25.01.2016			
Participants					
Does the research involve participants from any of the following groups?	• Children (under 16 years of age)	YES	NO	N/A	
	• People with learning difficulties		✓		
	• Patients (NHS approval is required)		✓		
	• People in custody		✓		
	• People engaged in illegal activities		✓		
	• Vulnerable elderly people		✓		
	• Any other vulnerable group not listed here		✓		
	• When working with children: I have read the Interim Guidance for Researchers Working with Children and Young People (http://www.cardiff.ac.uk/archi/ethics_committee.php)				✓
Consent Procedure					
• Will you describe the research process to participants in advance, so that they are informed about what to expect?	YES	NO	N/A		
• Will you tell participants that their participation is voluntary?	✓				
• Will you tell participants that they may withdraw from the research at any time and for any reason?	✓				
• Will you obtain valid consent from participants? (specify how consent will be obtained in Box A) ¹	✓				
• Will you give participants the option of omitting questions they do not want to answer?	✓				
• If the research is observational, will you ask participants for their consent to being observed?				✓	
• If the research involves photography or other audio-visual recording, will you ask participants for their consent to being photographed / recorded and for its use/publication?	✓				
Possible Harm to Participants					
• Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort?	YES	NO	N/A		
• Is there any realistic risk of any participants experience a detriment to their interests as a result of participation?		✓			
Data Protection					
• Will any non-anonymous and/or personalised data be generated or stored?	YES	NO	N/A		
• If the research involves non-anonymous and/or personalised data, will you:	• gain written consent from the participants	✓			
	• allow the participants the option of anonymity for all or part of the information they provide	✓			
Health and Safety					
Does the research meet the requirements of the University's Health & Safety policies? (http://www.cf.ac.uk/osheu/index.html)	YES				
	✓				
Research Governance					
Does your study include the use of a drug? You need to contact Research Governance before submission (resgov@cf.ac.uk)	YES	NO	N/A		
Does the study involve the collection or use of human tissue? You need to contact the Human Tissue Act team before submission (hta@cf.ac.uk)		✓			

¹ If any non-anonymous and/or personalised data be generated or stored, *written consent* is required.

If any of the shaded boxes have been ticked, you must explain in Box A how the ethical issues are addressed. If none of the boxes have been ticked, you must still provide the following information. The list of ethical issues on this form is not exhaustive; if you are aware of any other ethical issues you need to make the SREC aware of them.

Box A The Project (provide all the information listed below in a separate attachment)

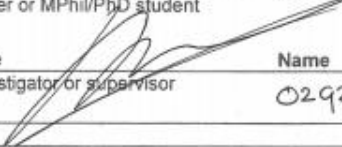
1. Title of Project
2. Purpose of the project and its academic rationale
3. Brief description of methods and measurements
4. Participants: recruitment methods, number, age, gender, exclusion/inclusion criteria
5. Consent and participation information arrangements - please attached consent forms if they are to be used
6. A clear and concise statement of the ethical considerations raised by the project and how is dealt with them
7. Estimated start date and duration of project

All information must be submitted along with this form to the School Research Ethics Committee for consideration

Researcher's declaration (tick as appropriate)

- I consider this project to have **negligible ethical implications** (can only be used if none of the grey areas of the checklist have been ticked).
- I consider this project research to have **some ethical implications**.
- I consider this project to have **significant ethical implications**

Signature  Name Adrienn Rokosni Date 25.01.2016
 Researcher or MPhil/PhD student

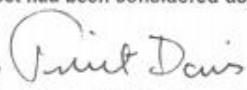
Signature  Name Professor Wouter Poortinga Date 25.01.2016
 Lead investigator or supervisor 02920 874 755

Advice from the School Research Ethics Committee

Please can the supervisor sign this.
 It seems a well constructed project.

STATEMENT OF ETHICAL APPROVAL

This project had been considered using agreed Departmental procedures and is now approved

Signature  Name JULIET DAVIS Date 12/02/2016
 Chair, School Research Ethics Committee

10.2. Occupant interview schedule

Before the interview:

- Check the participants have read the information sheet that was provided
- Ask participants if they have any questions about the study. If not, or when these questions have been addressed, invite the participants to read the consent form and if happy to do so to sign it
- Give a copy of the demographic questionnaire and invite participants to complete it

Ok. thank you for that. Now, if you are ready, we can begin the interview itself.

First, I would like to talk to you about how did you find and how did you choose this accommodation.

Interview

1. Meaning and experience of moving in

1. I was wondering whether moving into this energy efficient accommodation was an intentional decision, or whether it wasn't as clear as that? How was it for you?

Prompts:

- Why did you choose to move into this specific residence? How did you choose which accommodation to go for?
- Why do you think others selected this accommodation?

Note: After 1. round of interviews, the researcher realized the questions "Why do you think others selected this accommodation?" does not elicit responses supportive of the research and therefore can be omitted in future interviews.

Ok. Thank you for that. Now, let's talk about the first few days when you moved in.

2. Can you recall what were your first impressions about this building, about this dorm?

Prompts:

- How did you feel about the place when you were moving in?
- What were the things that you liked and that you didn't like?
- How do you think others around you liked it? What makes you say that?
 - Alternatively, perhaps you can tell me the story of how did you settle in during the first days? Can you walk me through those days?

Note: After 1. round of interviews, the researcher realized the questions "How do you think others around you liked it? What makes you say that?" does not elicit responses supportive of the research and therefore can be omitted in future interviews.

3. Have you noticed anything in the building or around the building that helped you, informed you or guided you in acting or using the building in a more environmentally friendly way?

Prompts:

- If yes, what was that? Was it immediately clear how to use it?

- Do you think others noticed those instantly? Do you think it was immediately clear to others how to use those features? Did others have the same reaction as you did?
- Did you talk about how to adequately use those features with your flatmates? Why? Why not?
- Did you receive any guidance on how to use the room, the building, and its features in an environmentally friendly way? How useful did you find that? / Do you think it would be useful to receive guidance on that?

II. Meaning and experience of living in

4. What does it mean to you now, if anything, that you live here, in this energy efficient accommodation?

Prompts:

- How important is that for you now? Why is it important? Why isn't it important?
- What do you think it means to the other students who live here? What do you think why is that?

Note: After I. round of interviews, the researcher realized the questions "What do you think it means to the other students who live here? What do you think why is that?" does not elicit responses supportive of the research and therefore can be omitted in future interviews.

5. Could you tell me more about how is it to live here in this energy efficient accommodation? How do you feel about the place now? What are the things about it that you like and the things that you didn't like? Why?

Prompts:

- What are the three words that come into your mind when you think about living in this sustainable accommodation?
- How do you think others like it? What makes you say that? What do you think why is that?

6. Can you tell me how do you experience the indoor environment, more specifically the lights, temperature, and air quality?

Prompts:

- Lighting: How are the lights in your room/flat/building? Is your room bright enough? Do you need to switch on the lights during the day? Why?
- Temperature: Does your room/flat/building get too cold or hot sometimes? What do you do when that happens?
- Air: How is the air in your room/flat/building? Is it fresh? Humid? Dry? Drowsy? What do you do when you want to change that?
- Do you think your flatmates have the same experience?

III. Practices and meaning of practices

Thank you. Now, I would like you to focus on how you use the space itself. I would like you to focus on some behaviours you perform daily or regularly in this building and have an impact on the environment.

7. Can you tell me about an activity you perform regularly which might potentially have an impact on the environment? You may talk about an activity that you mentioned in your diary, or you can mention anything that is linked with the:

Prompts:

- Light use (natural or artificial) – reading, reading lamp
 - *Note:* 1. set of interviews suggested that privacy may be leading to blind use and light use, therefore questions to explore the perception of privacy and associated behaviours were included here.
- Electricity use
- Space heating – Do you like to keep your room warm/cooler? How do you do that?
- Air quality – Do you often air your room? How do you do that?
- Hot /cold water usage – cooking, fridge use, tea preparation (kettle), showering, teeth washing, laundry, washing dishes, etc.
- Waste disposal – recycling

Note: Question might be asked for the activity reported in Question 7.

8. Why is that important to you? How do you do it? Why do you do it the way you do it?

Possible follow-up questions:

- Have you always performed these activities like this, even before moving in here? What do you think why is that?
- In what ways do you think you perform these actions similarly or differently from other people around you?

Repeat questions 7.and 8. for two or three activities.

IV. The perceived influence of the physical and social environment

Thank you so much. Now, I would like you to focus on the way the people who you live with and the building in which you live might affect your previously mentioned activities in the building.

9. Focusing on the behaviour we've just discussed, how do you think people around you help you or stand in your way in acting in an environmentally friendly way/ to living sustainably in the Halls?

Prompts:

- Can you give me an example for that? Maybe you can think about a specific experience or a particular time...?
- Do you think people around you expect you to behave/ to use the building in a certain way?
- Do you talk about the sustainability of the building and about how is it to live here and how to sustainably use the building with your flatmates?
- Do you think you influence other students who live in this accommodation?
- Do you think you influence each other? Could you tell me how?
- Do you think this was different in your previous accommodation? How was it different?

10. How do you think this building in which you live now, or any feature of this building influences you in terms of how you act from a environmental perspective? (focus on activities from question 8 and give some examples – if not choose other behaviours)

Prompts:

- Can you give me an example on how the building helps you or stands in your way to use it in an environmentally friendly, sustainable way? Maybe you can think about a specific experience or a particular time...
- Is there something that prompts you to use electricity, heat, hot water, lights in a smarter, more sustainable and less energy intensive way? Is there something that helps you to recycle?
- Do you think this was different in your previous accommodation? How was it different?

11. How do you think the accommodation could be further improved in some way to help residents act smarter from an ecological perspective? How the design of the space and the features of the space could be improved to provide you solutions that are greener but also better, easier, more exciting, inspirational, natural? What do you think what could help you to live a more sustainable life in the resi?

Prompts:

- Can you tell me an example how you imagine it could be improved?
- How would that help you to act in a more environmentally friendly way?
- You said the word ... could you described what did you mean by that?

OK. These were al my questions that I wanted to ask. Would you like to add anything? Anything that comes into your mind about this topic we have been discussing? Anything that maybe intrigued you about this sustainable building?

Thank you for taking part in this study. Have a nice day!

General prompts:

- What makes you say that?
- Could you say a little bit more about that?
- I wonder if you could give me an example.

How was it to write the diaries? How did you feel about it?

Have you noticed some changes in your behaviour and the way you use the accommodation since you started the diaries?

10.3. Occupant interview analysis snippets

Table 40. Initial coding

Interview transcript	Initial Codes
<p>PARTICIPANT: yeah, I don't like that (blind and light use) so as soon as I moved to another place that's something I wouldn't continue. I think the problem is that you know we are living in one room for our whole life, so, for our whole life during these years, so it's not like in a normal house where you wouldn't study or you work in your bedroom where you sleep, this is all your personal space in one spot and people can see straight in so you know if I would set in a proper house and someone was walking past and I would sit in the lounge I don't really care from the desk, I don't really care too much, I don't know it's probably because I'm right next to the front door, everybody walks past and I don't really like the idea of looking in and see what I'm doing on my computer, it's that close proximity I think... if it was, if it was 10-15 meters off I would be fine, they wouldn't see the computer screen that I'm using something they wouldn't see what I was writing or anything, but at that distance they can see and that, that is annoying but yeah, once I left yeah I wouldn't continue that habit of closing the curtains and switch on the light, I don't like it...yeah, I like to have the lights come in</p> <p>INTERVIEWER: You mentioned that in the morning after you dress up you used to open the blinds because it's ok not to use the lights but is that brightness enough to do your activities in your room?</p> <p>PARTICIPANT: that depends on the time of the year and the time of the day because sometimes, especially during the winter it's quite dark, you know, during the morning and if the sun doesn't rise on your side of the building than this is such a big building, you've got very bad light and so weary unless you want to be in semi-darkness you need the light on and again that's the balance between total privacy or lights and to pull the blind out, so when it was really dark what I normally do is that I switch on the bedside light just to have a bit of light in the room, I sit at the desk and I leave the curtain on ...yeah, just because the pathway is literally right next to my window, if it was 10 meters off I wouldn't care but ... Naturally, people can see in that is just a bit too much ...</p> <p>Yeah...that's quite an annoying thing I think...as I think I mentioned in my calendarI couldn't have privacy but if you switch on the light inside the room than people will see in despite that so that's why I wait until it gets slightly dark than I put down the slides, the curtain before I switch on the light...so people can't see in...just for privacy</p> <p>INTERVIEWER: Yeah... Do you think you would use the lights and the blinds differently if you weren't at the ground floor?</p> <p>PARTICIPANT: definitely, yeah...as I said I lived much higher last year and because there was no one able to look in I kept the window much more...the blinds much more open and relied less on the (artificial) lights</p>	<p>Disliking artificial light use during the day Planning to stop the bad habit after relocation Finding it problematic to live in one space</p> <p>Contrasting housing with resis on multiple functions of bedroom Having privacy restricted to room/ Being seen by people Discussing being in lounges or work areas of homes</p> <p>Being careless of glimpses in the living or work areas</p> <p>Disliking people can see computer screen when walking by</p> <p>Projecting acceptable distance of pathways for not seeing the computer screen Reiterating on dislike for being seen Reiterating on not wanting to close blinds and turn on lights Appreciating natural light</p> <p>Experiencing the room dark during winters</p> <p>Believing building size and room orientation causes poor light level in room Needing artificial lights due to weary natural lights Balancing privacy, light use, and blind use Using bedside light to read on darker days Sitting at the desk and leaving curtains on Reiterating on proximity of pathways Projecting 10 meters distance to make him not care Finding external glances too much to take in</p> <p>Referring to diary Being annoyed by the lack of privacy Feeling being seen through the window Closing blinds Turning on lights Explaining light and blind use with privacy</p> <p>(researcher reacting to emerging story) Remembering living on upper floor (in same building) Not feeling seen on upper floor Remembering keeping blinds open more Remembering less reliance on artificial lights</p>

Table 41. Early memo snippet.

Early memo snippet: Light use in the rooms

(J) prefers working with daylight and dislikes using artificial lights during the day, however he relies extensively on artificial lights during the day and considers it a bad habit. He reasons artificial light use with closed blinds, which are necessary for him to protect his privacy. Privacy seems to be a major concern to students since in the residence their rooms are the only private areas they have. This might be quite a resi-specific phenomenon. For (J) privacy, more exactly the lack of privacy, is the feeling of being seen through the window by 'others'. He thinks others can see his computer screen when they enter the building, since he lives next to the entrance on the ground floor, and thinks the pathways are too close to his window. He also mentions that when living on higher floors, he did not have privacy concerns to such extent and used to keep the blinds open and work with daylight. He also thinks he will change the habit of closing blinds during the day once he moves out from the student accommodation. Although, he refers to the action chain of closing blinds and turning on lights during the day as a habit, it might not necessarily be a habit. Since he wasn't doing it on higher floors, is keen on not doing it when he changes residence, and he does it because he feels he can be seen, makes me think this is a contextually queued behaviour chain triggered by his perception of diminished privacy in his room. (F) also has the same concerns as (J) and reports closing blinds to protect his privacy and then he turns on the light. Similarly, to (J), he lives on the ground floor. Also, the way (Si) uses the blinds during some activities is dependent on his 'mood' and on the momentary desire for privacy.

(J, F and Si) prefer natural lights but sacrifice having natural light to protect their privacy.

Note to self: raise privacy and associated light use behaviours in rooms during future interviews since this may be highly specific to accommodations and may be significantly impactful on sustainability of sustainable buildings.

Additionally, natural light in the rooms is sometimes perceived to be weary due to orientation, building size (J), vegetation (trees) in front of the window (Si), or even due to the season of the year, and occupants report using reading lamps or other artificial light sources to counter that (J, Si, F). That is, occupants may be relying on artificial light during the day if the indoor light levels ensured by the overall design are perceived as insufficient and hence visually uncomfortable.

Furthermore, (Si) reports that since the table is too close to the window, he experiences glare (discomfort). In order to mitigate that, he uses the blinds during the day and then may turn on artificial lights as well to ensure satisfactory light levels. Again, it seems to be a behaviour queued by the environment/context (perceived light coming through the window + furniture arrangement of the room) rather than a deeply entrenched habit they may have brought from with them. Or maybe it is a habit developed on site since habits can be/are queued by the context.

Finally, some of the residents, (N) and (F), leave the lights on during the night either for feeling safe or just to use it as guidance. This may mean that a minimal amount of light is comforting for them during the night since it ensures a certain level of visibility. To achieve that comfort, they use bathroom lights all night long which may be environmentally detrimental. However, this behaviour pattern seems significantly different from the daylight use in the rooms, since there is no natural light they may use instead of the artificial lights. *Note to self: To keep separate.*

Table 42. Focus Coding

Interview transcript	Focus Codes
<p>PARTICIPANT: yeah, I don't like that (blind and light use) so as soon as I moved to another place that's something I wouldn't continue. I think the problem is that you know we are living in one room for our whole life, so, for our whole life during these years, so it's not like in a normal house where you wouldn't study or you work in your bedroom where you sleep, this is all your personal space in one spot and people can see straight in so you know if I would set in a proper house and someone was walking past and I would sit in the lounge I don't really care from the desk, I don't really care too much, I don't know it's probably because I'm right next to the front door, everybody walks past and I don't really like the idea of looking in and see what I'm doing on my computer, it's that close proximity I think... if it was, if it was 10-15 meters off I would be fine, they wouldn't see the computer screen that I'm using something they wouldn't see what I was writing or anything, but at that distance they can see and that, that is annoying but yeah, once I left yeah I wouldn't continue that habit of closing the curtains and switch on the light, I don't like it...yeah, I like to have the lights come in.</p> <p>INTERVIEWER: You mentioned that in the morning after you dress up you used to open the blinds because it's ok not to use the lights but is that brightness enough to do your activities in your room?</p> <p>PARTICIPANT: that depends on the time of the year and the time of the day because sometimes, especially during the winter it's quite dark, you know, during the morning and if the sun doesn't rise on your side of the building than this is such a big building, you've got very bad light and so weary unless you want to be in semi-darkness you need the light on and again that's the balance between total privacy or lights and to pull the blind out, so when it was really dark what I normally do is that I switch on the bedside light just to have a bit of light in the room, I sit at the desk and I leave the curtain on ...yeah, just because the pathway is literally right next to my window, if it was 10 meters off I wouldn't care but ... Naturally, people can see in that is just a bit too much ...</p> <p>Yeah...that's quite an annoying thing I think...as I think I mentioned in my calendarI couldn't have privacy but if you switch on the light inside the room than people will see in despite that so that's why I wait until it gets slightly dark than I put down the slides, the curtain before I switch on the light...so people can't see in...just for privacy</p> <p>INTERVIEWER: Yeah...Do you think you would use the lights and the blinds differently if you weren't at the ground floor?</p> <p>PARTICIPANT: definitely, yeah...as I said I lived much higher last year and because there was no one able to look in I kept the window much more...the blinds much more open and relied less on the (artificial) lights</p>	<p>Preference for natural lights</p> <p>Outstanding importance of privacy in student rooms</p> <p>Privacy loss due to sense of being seen through the window</p> <p>Privacy loss due to perceived pathway proximity</p> <p>Closing blinds to protect privacy and then turning on lights</p> <p>Privacy trumping preference for natural light</p> <p>Lacking natural light</p> <p>Lacking natural light due to building size and room orient. Using artificial lights in lieu of natural light Balancing privacy, blind closing and artificial light use</p> <p>Using artificial lights in lieu of natural light</p> <p>Privacy loss due to perceived pathway proximity</p> <p>Closing blinds to protect privacy and turning on lights</p> <p>Privacy gains on higher floors Keeping blinds open(priv.) and using less lights on higher floors</p>

Table 43. Memo snippet

Memo snippet: Daytime light use in the rooms

My main concern at this point is what may constitute a category and the related sub-categories? Participants seem to discuss very specific environmentally significant behaviours (ESB) or behaviour chains as one phenomenon. So those may be conceptualized as categories. However, each of those behaviour chains seem to be related to how students perceive some parts of their physical environment fit specific expectations or needs. This hints towards the fact that the elements of the physical environment, the design features of the accommodation may be sub-categories, the needs occupants perceive as being supported are another sub-category and the behaviours performed are a third sub-category. However, these sub-categories together - as they relate to each other – seem to explain to some extent specific phenomena/category, and not by themselves.

For the phenomenon of daytime light use in rooms, what seems relevant is how occupants perceive the design features such as windows, shading devices, building/window orientation, building size, floor level make them perceive their needs and expectations are satisfied. It's not one design feature, it is many that are interrelated and together are perceived in certain ways by occupants. The window seems central since it is the core feature through which occupants receive natural light, look out into the world or receive the often-undesired glimpses from others. So, the window with its adjacent design features constitute the sub-category of daytime light use in rooms category.

It is also clear that occupants need daylight to work without artificial lights and need to feel private not to close the blinds and turn on lights. The need for daylight may be considered as some form of Visual Comfort Need while the need for privacy relates to Visual Privacy of not being seen through the windows, both driven by occupant perception of how much is appropriate and satisfying. Similarly, discomfort glare is a perception of the individual that 'dictates' when glare may be uncomfortable and may trigger closing blinds and using artificial lights. Therefore, Discomfort Glare is a sub-dimension of Visual Comfort together with Daylight Visual Comfort and together with Visual Privacy form the Comfort sub-category.

The third sub-category are the light use behaviours. In this case, it encompasses natural light use, artificial light use, and closing and opening the blinds.

However, the core matter here seems to be the relationship between the sub-categories of features, sub-categories needs and sub-categories of behaviours. These together may explain the light use phenomenon in the rooms, which is also a category, that occurs in the accommodation rooms and result in ESB of occupants. And this seems to be part of the overall theoretical understanding that is emerging from these interviews.

...

10.4. Occupant Survey Study – Ethical Approval

EC1702.307.

WELSH SCHOOL OF ARCHITECTURE
ETHICS APPROVAL FORM FOR STAFF AND PHD/MPHIL PROJECTS

WS

Tick one box: STAFF PHD/MPHIL

Title of project: Living sustainably in sustainable student accommodations (SSA): The relationship between the need considerate qualities of design features incorporated in SSA and the environment affecting behaviours of residents *— confusing title*

Name of researcher(s): Adrienn Rokosni
 Name of principal investigator: Professor Wouter Poortinga
 Contact e-mail address: RokosniA@cardiff.ac.uk
 Date: 13.02.2017

Participants		YES	NO	N/A
Does the research involve participants from any of the following groups?	• Children (under 16 years of age)		✓	
	• People with learning difficulties		✓	
	• Patients (NHS approval is required)		✓	
	• People in custody		✓	
	• People engaged in illegal activities		✓	
	• Vulnerable elderly people		✓	
• Any other vulnerable group not listed here			✓	
• When working with children: I have read the Interim Guidance for Researchers Working with Children and Young People (http://www.cardiff.ac.uk/archi/ethics_committee.php)				✓

Consent Procedure		YES	NO	N/A
• Will you describe the research process to participants in advance, so that they are informed about what to expect?		✓		
• Will you tell participants that their participation is voluntary?		✓		
• Will you tell participants that they may withdraw from the research at any time and for any reason?		✓		
• Will you obtain valid consent from participants? (specify how consent will be obtained in Box A) ¹		✓		
• Will you give participants the option of omitting questions they do not want to answer?		✓		
• If the research is observational, will you ask participants for their consent to being observed?				✓
• If the research involves photography or other audio-visual recording, will you ask participants for their consent to being photographed / recorded and for its use/publication?				✓

Possible Harm to Participants		YES	NO	N/A
• Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort?			✓	
• Is there any realistic risk of any participants experience a detriment to their interests as a result of participation?			✓	

Data Protection		YES	NO	N/A
• Will any non-anonymous and/or personalised data be generated or stored?		✓		
• If the research involves non-anonymous and/or personalised data, will you:	• gain written consent from the participants	✓		
	• allow the participants the option of anonymity for all or part of the information they provide	✓		

Health and Safety		YES	NO	N/A
Does the research meet the requirements of the University's Health & Safety policies? (http://www.cf.ac.uk/osheu/index.html)		✓		

Research Governance		YES	NO	N/A
Does your study include the use of a drug? You need to contact Research Governance before submission (resgov@cf.ac.uk)			✓	

¹ If any non-anonymous and/or personalised data be generated or stored, *written consent* is required.

Does the study involve the collection or use of human tissue?
 You need to contact the Human Tissue Act team before submission (hta@cf.ac.uk)

If any of the shaded boxes have been ticked, you must explain in Box A how the ethical issues are addressed. If none of the boxes have been ticked, you must still provide the following information. The list of ethical issues on this form is not exhaustive; if you are aware of any other ethical issues you need to make the SREC aware of them.

Box A The Project (provide all the information listed below in a separate attachment)

1. Title of Project
2. Purpose of the project and its academic rationale
3. Brief description of methods and measurements
4. Participants: recruitment methods, number, age, gender, exclusion/inclusion criteria
5. Consent and participation information arrangements - please attached consent forms if they are to be used
6. A clear and concise statement of the ethical considerations raised by the project and how is dealt with them
7. Estimated start date and duration of project

All information must be submitted along with this form to the School Research Ethics Committee for consideration

Researcher's declaration (tick as appropriate)

- I consider this project to have **negligible ethical implications** (can only be used if none of the grey areas of the checklist have been ticked).
- I consider this project research to have **some ethical implications**.
- I consider this project to have **significant ethical implications**.

Signature *[Signature]* Name Adrienn Rokosni Date 13.02.2017

Researcher or MPhil/PhD student

Hard copy was signed by supervisor then Ethics Chair requested

Signature *[Signature]* Name Professor Wouter Poortinga Date 13.02.2017

Lead investigator or supervisor

Advice from the School Research Ethics Committee

The questionnaire is good and the information sheet for participants in the research is well written. However the description of the project given in Box A, including the title, is poorly explained. This could do with some further development, though it is not an ethical issue as such.

STATEMENT OF ETHICAL APPROVAL

This project had been considered using agreed Departmental procedures and is now approved *Reviewed 14.03.17*

Signature *[Signature]* Name *Juliet Davis* Date

Chair, School Research Ethics Committee

Questionnaire

Living in Sustainable Student Residences

Information Sheet

Welcome!

Below you will find an overview on the nature of the research and what participating in it means to you.

Before you make your decision, it is important for you to understand the purpose of the research and what it will entail. Please take time to read the following information carefully.

What is the study about? The study aims to understand how young adults, like yourself, who have moved into sustainable student accommodations, experience and use their new environments. This will help understand how student residences could be improved to better support pro-environmental behaviour of the occupants while ensuring comfortable living.

What does the research entail? The research consists of completing an easy questionnaire that only requires approximately 5-10 minutes of your time.

Prize! Those who complete the questionnaire and answer all questions can enter a prize draw and can become the lucky winners of one of the prizes:

- 1st prize: £100.00
- 2nd prize: £60.00
- 3rd prize: £40.00

The expected end date for the survey is 15 April 2017. The expected date of the prize draw is 31 April 2017.

What will happen to my information? The data from the questionnaire will be processed, anonymized, analyzed and it will be used for my PhD dissertation, which will be assessed and evaluated by Cardiff University. All information will be kept private throughout the duration of the PhD research. The information you provide will also be used in anonymized form as basis of articles published in academic journals. If you are interested, you are welcome to see the final thesis or read the articles before the publication.

Couple of words about me. My name is Adrienn Rokosni and I am a research PhD candidate at Cardiff University, Welsh School of Architecture. I am supervised by two Professors of the Welsh School of Architecture: Professor Wouter Poortinga and Professor Chris Tweed. The research was granted ethical approval by the School Research Ethics Committee and is jointly funded by the

Welsh School of Architecture and the EPSRC.

If you have any questions on the study, feel free to contact me by email at RokosniA@cardiff.ac.uk. I look forward to hearing from you.

Q1. Did you read and understand the information provided in this Information Sheet section?

Required



Yes, I understood the information provided on the Information Sheet



No, I have not understood all the information from the Information Sheet

Consent Form - Confidential Data

I understand that my participation in this research will entail completing a questionnaire where I will be asked questions about:

- my experiences with the physical features of the student residence where I live
- my experiences of the indoor environmental qualities of the student residence where I live
- how I use the features of the student accommodation
- general information about the student accommodation where I live
- general information about myself as part of demographic data

I am aware that completing the questionnaire will require approximately 5-10 minutes of my time.

I understand that my participation in this study is voluntary and that I can withdraw from the study at any time without giving a reason. I am aware that I can omit answering any of the questions. I understand that I am free to ask the Investigator any questions related to the study at any time before I decide to participate. I am also free to discuss my concerns with the supervisor, Professor Wouter Poortinga.

I understand that the information provided by me will be held confidentially, such that only the Investigator Adrienn Rokosni can trace this information back to me individually. I understand that the generated data will be kept in identifiable form for 3 months however, I am aware that I can ask for anonymity for all or part of my data at any time. I understand that in accordance with the Data Protection Act, I can have access to the information and I can ask for the information I provide to be deleted and destroyed at any time throughout the period the data is still identifiable.

While the data itself is non-anonymous, no personal information will ever be published. The results of the research will be reported so that participants cannot be identified. I also understand that after the data is anonymized I will not have the possibility to have access to my data. All anonym data will be retained until the PhD of the Investigator is finalized, when it will be deleted and destroyed.

Q2. Have you understood the consent form in full and do you consent to participate? Required



Yes, I agree to the terms of confidential data use and I consent to participate.



No, I do not agree to these terms.

Section 1. The lights in your student room

Before answering the following questions, please take a couple of seconds to picture the lights in your student room during the day.

Q3. To what extent do you agree or disagree with the following statements:

(Please tick one answer for each statement)

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Q3_1. On <u>sunny days</u> , there is glare in my room.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q3_2. On <u>sunny days</u> , the sun overheats my room.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q3_3. On a <u>typical day</u> , I can read a book without using any of the lamps in my room.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q3_4. On a <u>typical day</u> , I feel people can see me through the window.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q3_5. On a <u>typical day</u> , my room is bright.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q4. On a typical sunny day, between which hours of the day does the Sun shine into your room?

(Please tick all that apply)

6am-9am	9am-12am	12am-2pm	2pm-5pm	5pm-8pm	Never/My room does not get direct sunlight
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q5. Between which hours of the day do you keep the blinds closed in your room?

(Please tick all that apply)

6am-9am	9am-12am	12am-2pm	2pm-5pm	5pm-8pm	Never/Not applicable
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q6. If your blinds are ever closed during the day please indicate, What would be the reasons for you to keep the blinds/curtains closed in your room during the day?

(Please select all that apply)

- People can see into my room
- The sun can cause glare
- The sun overheats my room
- Other reason (please specify in couple of words):

Q7. On a typical sunny day, between which hours of the day do you use the following lights in your room?

(Please tick all that apply)

	6am-9am	9am-12am	12am-2pm	2pm-5pm	5pm-8pm	Never/Not applicable
Main lights	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Desk lights	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Bedside lamp	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Q8. On a typical cloudy day, between which hours of the day do you use the following lights in your room?
 (Please tick all that apply)

	6am-9am	9am-12am	12am-2pm	2pm-5pm	5pm-8pm	Never/Not applicable
Main lights	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Desk lights	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bedside lamp	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q9. If you use any of the lights during the day please answer the following question.
What would be the reasons for you to use the lights in your room during the day?
 (Please select all that apply)

- The blinds/curtains are closed so it's a bit dark in the room during the day
- It is a bit dark in my room during the day, even with the blinds/curtains open
- The natural light doesn't reach well to the part of the room where I am doing my daily tasks
- Other reason (please specify in couple of words):

Section 2. The lights in the kitchen area

Before answering the questions of this section please take a couple of seconds to think about the lights in the kitchen and living area of your student flat during the day.

Q10. To what extent do you agree or disagree with the following statement:
 (Please tick one box)

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
On a <u>typical</u> day there is plenty of natural light in the kitchen, even without the lights on.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q11. Please answer the following questions regarding the artificial lights in the kitchen during the day.
 (Please tick all that apply)

	6am-9am	9am-12am	12am-2pm	2pm-5pm	5pm-8pm	Never/Not applicable
Q11_1. Between which hours of the day are the lights on in the kitchen?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q11_2. Between which hours of the day are the lights on in the kitchen even if there is plenty of sunlight?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q12. Which of the following applies to your kitchen light controls?
 (Please tick one box)

- The lights are fully automatic
- The lights have manual switch only
- The lights are automatic but there is also a manual switch

Q13. If the kitchen lights are ever on during the day, please answer the next question.

Which of the following describe the reasons for having the lights on in the kitchen during the day?

(Please tick all that apply)

- The kitchen lights cannot be turned off manually
- I/Flatmates forget to turn off the kitchen lights
- The kitchen is too dark without the lights on
- Other reason (please specify in couple of words):

Before answering the following questions please take a couple of seconds to think about how are the kitchen/living areas in your student flat during the evening, how are the lights, and what do you and your flatmates do in the kitchen/living area during the evening?

Q14. Have you or your flatmates ever wanted to have the lights OFF (or to dim the lights) in the kitchen/living area during the evening when using the space? (for watching movies or partying for instance)

(please tick one box)

- Yes
- No

Q15. If you ticked 'Yes' at question 5 please answer the following question.

What activities do you or your flatmates perform in the kitchen, for which you or your flatmates would want the lights OFF (or dimmed) during the evening?

(Please tick all that apply)

- Watching movies
- Playing video games
- Flat partying
- Hanging out with friends or flatmates
- Other (please describe in couple of words)

Q16. If you answered 'Yes' at question 5 please answer the following question.

How many times per month do you or your flatmates would want to keep the lights OFF (or dimmed) in the kitchen during the evening?

(Please tick one box)

Less than twice a month

2-4 times a month

5-9 times a month

More than 10 times a month

Q17. If you answered 'Yes' at question 5 please answer the following question.

When you want to keep the lights OFF (or dimmed) in the kitchen during the evening, how do you turn the lights OFF?

(Please tick all that apply)

- By using the manual switch
- By covering the motion sensor so it does not turn on the lights
- I cannot turn it off
- Other (please specify in couple of words):

Section 3. Heating and ventilating the student rooms

Before answering the questions of this section please take a couple of seconds to think about the temperature and air quality of your student room.

18. On a typical winter day, how would you rate the temperature in your room?

(Please tick one box)

Very hot	Hot	Neither hot nor cold	Cold	Very cold
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q19. What is the average number of hours the heating is ON in your room on typical winter days?

(Please tick one box)

	Less than 1 hour	Between 1 and 2 hours	Between 2 and 4 hours	Between 4 and 8 hours	More than 8 hours
During the day	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
During the night	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q20. At what setting do you usually use the heating in your room on typical winter days?

(Please tick one box in each line)

	0 Off	1	2	3	4	5 Max	Other/Please specify
During the day	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
During the night	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Q21. If you have a second, private, electric heater in your room please answer the following question.

On winter days, how many hours a day is your second heater on ?

(Please tick one box in each line)

	Less than 1 hour	Between 1 and 2 hours	Between 2 and 4 hours	Between 4 and 8 hours	More than 8 hours
During the day	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
During the night	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How would you rate the air in your room on the following qualities?

(Please tick one box for each row)

	Very humid	Humid	Neither humid nor dry	Dry	Very dry
Q22. Humidity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Very draughty	Draughty	Neither draughty nor still	Still	Very still
Q23. Air flow	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Very fresh	Fresh	Neither fresh nor stuffy	Stuffy	Very stuffy
Q24. Freshness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q25. In colder periods of the year, how many hours a day, on average, do you use the following devices for ventilation ?

(Please tick one box in each row)

	Less than 1 hour	Between 1 and 2 hours	Between 2 and 4 hours	Between 4 and 8 hours	More than 8 hours	Never/ Not applicable
Window	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Trickle vents (ex1 , ex2)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q26. In colder periods of the year , how many hours a day, on average, is your window open when the heating is ON?

(Please tick one box)

Less than 1 hour	Between 1 and 2 hours	Between 2 and 4 hours	Between 4 and 8 hours	More than 8 hours	Never/ Not applicable
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q27. If the window in your room is ever open while the heating is ON please answer this question.

What would be the reasons for opening the window while the heating is ON?

(Please tick all that apply)

- If I close the window the air is stuffy
- The heating is too strong and it overheats my room
- I am used to keeping the window open
- Other (please specify in couple of words):

Section 4. Waste management and recycling facilities

Before answering the following questions please take a couple of seconds to think about the waste bins available to you in your student flat.

Q28. What kind of waste bins do you have in the following areas of your student flat.

(Please tick all that apply)

	General waste bin	Recycle bin	Food waste bin	None/ No waste bin
In your room	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
In the kitchen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q29. Please indicate which of the following features apply to the waste bins in the kitchen area.

(Please tick all that apply)

- Colour of the bins are different for the different waste types
- Size of the bins are different for the different waste types
- Shape of the bins are different for the different waste types
- Visual instructions on the bins indicate the waste types
- Size and shape of the openings on the bins are different for the different waste types
- Colour of installed waste bags are different for the different waste types
- The waste bins are visually identical

Q30. Please rate how easy it is to use the following bins in the kitchen.

(Please tick one box in each row)

	Very easy	Easy	Neither easy nor complicated	Complicated	Very complicated
General waste bin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Recycle bin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Food waste bin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q31. Please rate how clean it is to use the following bins in the kitchen.

(Please tick one box in each row)

	Very clean	Clean	Neither clean nor dirty	Dirty	Very dirty
General waste bin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Recycle bin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Food waste bin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q32. Do you ever change the bags in the waste bins from the kitchen?

(please tick one box)

- Yes
 No

Q33. If you answered Yes to question 32,

Please rate how easy it is to change the bags in the following bins from the kitchen?

(Please tick one box in each row)

	Very easy	Easy	Neither easy nor complicated	Complicated	Very complicated
General waste bin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Recycle bin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Food waste bin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q34. If you answered Yes to question 32,

Please rate how clean you find changing the bags in the bins from the kitchen.

(Please tick one box in each row)

	Very clean	Clean	Neither clean nor dirty	Dirty	Very dirty
General waste bin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Recycle bin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Food waste bin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q35. How often do you recycle in the following areas of your student flat?

(Please tick one box in each row)

	Always	Often	Occasionally	Never	Not applicable
Q35_1. In your room	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q35_2. In the kitchen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q36. Which of the bins do you use to dispose of the following waste types?

(Please tick all that apply)

	Recycle bin	Food waste bin	General waste bin
Dirty tissues or used paper kitchen towel	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Plastic water bottles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Plastic shopping bags	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Glass bottles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Food you don't want anymore	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Paper packaging of food	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Soft drink/beer cans	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pizza boxes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pizza leftovers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sheets of paper with notes, newspaper, magazines	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fruit peel (banana, orange...)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q37. If you always or often recycle in the kitchen, which of the following statements describe the reasons why you recycle?

(Please select all that apply)

- I recycle because it is a general requirement in my accommodation
- I recycle because I think it is important
- I recycle because I see everybody recycles around here
- I recycle because it is easy to do it
- Other (please specify in couple of words):

Q38. If you don't recycle or recycle only occasionally in your student flat, which of the following statements describe the reasons why you don't recycle?

(Please select all that apply)

- My flatmates don't recycle either
- I don't recycle because the bins are messy
- I don't think recycling is important
- I don't recycle because it is not a requirement
- I don't recycle because nobody explained how
- I don't recycle because I find it inconvenient
- I don't recycle because it is complicated
- I don't recycle because I think waste is mixed up anyhow in the end
- Other (please specify in couple of words):

Before answering the questions of this section please take a couple of seconds to think about where you take out the waste from the flat. If the waste from the flat is being collected by staff please ignore the questions of this section.

Q39. Which of the following features do the outside waste bins (or shafts) have?

(Please tick all that apply)

- The bins have different colours for the different waste types.
- The bins are grouped together for the different waste types.
- The bins have different size for the different waste types.
- The bins have different shapes for the different waste types.
- The bins have different visual instructions for the different waste types.
- The size and shape of the openings on the bins differ for the different waste types.
- The bins are visually identical.

Q40. To what extent do you agree or disagree with the following statements related to the outside waste bins (or shafts).

(Please tick one box in each row)

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree	Don't know/ Not applicable
It is <u>easy</u> to open the outside waste bins.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
A normal waste bag <u>fits easily</u> though the opening/lid of the outside waste bins (or shaft)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The shape of the openings on the outside recycle waste bins are <u>suggestive</u> of what type of waste it should hold. (example: round openings for bottles)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The outside waste bins are <u>clean</u> .	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q41. When taking out the waste, some students drop off the waste bags in the same bins/shafts, others make sure they place the bags separately by different waste types. How about you?

When you take out the waste, how often do you separate by waste type?

(Please tick one box)

Always	Often	Occasionally	Never
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q42. If you answered Occasionally or Never to Question 14, please answer the following question.

Which of the followings describe the reasons you don't separate by waste type into the designated bins (or waste shafts) outside your student flat?

(Please tick all that apply)

- The bins are all mixed together
- All the large bins look the same
- The bags in the large bins are already mixed up
- A usual waste bag doesn't fit through the opening of the bins/shafts
- I never take out the waste
- Other (please specify in couple of words):

Q43. If you answered *Always* or *Often* to Question 14, please answer the following question.
Based on what do you differentiate in which outside bin (or shaft) to drop off the recycled waste and the refuse waste bags?

(Please tick all that apply)

- Based on the colour of the bins
- Based on the size of the bins
- Based on the visual instructions on the bins
- Based on the size and shape of the openings on the bins
- Based on the grouping of the bins
- Other (please specify in couple of words):

Section 5. About you

Finally, in order to compare the views of different people please could you tell me a bit about yourself:

Q44. Please specify your gender:

- Female Male

Q45. Please specify your age:

years

Q46. Please specify your nationality:

Q47. Please specify what are you studying:

Q48. What is the name of the student accommodation you live?

Q49. When did you move into your current student accommodation? (approximately)

Q50. On which floor do you live? (Please write a number: 0 for Ground floor, 1 for First floor and so forth...)
Floor

Q51. How many flatmates do you have?

Prize draw participation

Thank you for completing this questionnaire. If you wish to be included in the free prize draw (1st Prize is £100, 2nd Prize is £60, 3rd Prize is £40), please complete the information below.

Would you like to be entered into our free prize draw?

- Yes No

(please tick one box)

Would you be willing to be contacted for short follow-up discussions?

- Yes No

(please tick one box)

If Yes to any of the two questions, please provide your contact details below. These details will be treated

confidentially and will not be passed onto to any other individuals or organisations.

Full name:

Email address:

(Please specify your university email as far as possible, for example: JaneDoe@youruni.ac.uk)

Thank you for completing this questionnaire!

Please save the completed questionnaire and return it by email to rokosnia@cardiff.ac.uk

Thank you!

10.6. Architect Interview Study – Ethical Approval

EC1607.287


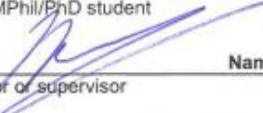
WELSH SCHOOL OF ARCHITECTURE ETHICS APPROVAL FORM FOR STAFF AND PHD/MPHIL PROJECTS		WSA		
Tick one box:	<input type="checkbox"/> STAFF	<input checked="" type="checkbox"/> PHD/MPHIL		
Title of project:	Designing and operating sustainable student accommodations: how far is supporting residents pro-environmental behaviour part of the design and operation agenda of sustainable student accommodations			
Name of researcher(s):	Adrienn Rokosni			
Name of principal investigator:	Professor Wouter Poortinga			
Contact e-mail address:	RokosniA@cardiff.ac.uk			
Date:	10.08.2016			
Participants				
Does the research involve participants from any of the following groups?	• Children (under 16 years of age)	YES	NO	N/A
	• People with learning difficulties		✓	
	• Patients (NHS approval is required)		✓	
	• People in custody		✓	
	• People engaged in illegal activities		✓	
	• Vulnerable elderly people		✓	
	• Any other vulnerable group not listed here		✓	
• When working with children: I have read the Interim Guidance for Researchers Working with Children and Young People (http://www.cardiff.ac.uk/archi/ethics_committee.php)				✓
Consent Procedure				
• Will you describe the research process to participants in advance, so that they are informed about what to expect?		✓		
• Will you tell participants that their participation is voluntary?		✓		
• Will you tell participants that they may withdraw from the research at any time and for any reason?		✓		
• Will you obtain valid consent from participants? (specify how consent will be obtained in Box A) ¹		✓		
• Will you give participants the option of omitting questions they do not want to answer?		✓		
• If the research is observational, will you ask participants for their consent to being observed?				✓
• If the research involves photography or other audio-visual recording, will you ask participants for their consent to being photographed / recorded and for its use/publication?		✓		
Possible Harm to Participants				
• Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort?			✓	
• Is there any realistic risk of any participants experience a detriment to their interests as a result of participation?			✓	
Data Protection				
• Will any non-anonymous and/or personalised data be generated or stored?		✓		
• If the research involves non-anonymous and/or personalised data, will you:	• gain written consent from the participants	✓		
	• allow the participants the option of anonymity for all or part of the information they provide	✓		
Health and Safety				
Does the research meet the requirements of the University's Health & Safety policies? (http://www.cf.ac.uk/osheu/index.html)		✓		
Research Governance				
Does your study include the use of a drug? You need to contact Research Governance before submission (resgov@cf.ac.uk)			✓	

¹ If any non-anonymous and/or personalised data be generated or stored, *written consent* is required.


Does the study involve the collection or use of human tissue? You need to contact the Human Tissue Act team before submission (hta@cf.ac.uk)		✓
---	--	---

If any of the shaded boxes have been ticked, you must explain in Box A how the ethical issues are addressed. If none of the boxes have been ticked, you must still provide the following information. The list of ethical issues on this form is not exhaustive; if you are aware of any other ethical issues you need to make the SREC aware of them.

Box A	The Project (provide all the information listed below in a separate attachment)
1. Title of Project 2. Purpose of the project and its academic rationale 3. Brief description of methods and measurements 4. Participants: recruitment methods, number, age, gender, exclusion/inclusion criteria 5. Consent and participation information arrangements - please attached consent forms if they are to be used 6. A clear and concise statement of the ethical considerations raised by the project and how is dealt with them 7. Estimated start date and duration of project All information must be submitted along with this form to the School Research Ethics Committee for consideration	

Researcher's declaration (tick as appropriate)		
• I consider this project to have negligible ethical implications (can only be used if none of the grey areas of the checklist have been ticked).	<input type="checkbox"/>	
• I consider this project research to have some ethical implications .	<input checked="" type="checkbox"/>	
• I consider this project to have significant ethical implications	<input type="checkbox"/>	
Signature 	Name Adrienn Rokosni	Date 10.08.2016
Researcher or MPhil/PhD student		
Signature 	Name Professor Wouter Poortinga	Date 10.08.2016
Lead investigator or supervisor		

Advice from the School Research Ethics Committee

STATEMENT OF ETHICAL APPROVAL		
This project had been considered using agreed Departmental procedures and is now approved		
Signature 	Name <u>8/8/2016</u> Andrew Roberts	Date
Chair, School Research Ethics Committee		

10.7. Architect interview schedules

Daniel Defoe Hall - Architect Interview Schedule

Interview preparation

Date: 01.11.2016, 10:00-10:45

Location: One America Street, London, SE1 ONE

Participant pseudonym: Kris

Architect background: BArch, RIBA, Project Director

From website:

“(Kris@DDH) studied architecture at ---- graduating in ----. In ---- he moved to London and continued his post-graduate research at the Bartlett School of Architecture.

Early in his career (Kris@DDH) was responsible for a major mixed development in the Isle of Dogs and the refurbishment of the five star Balmoral Hotel in Edinburgh. He then established his own practice undertaking work in the London corporate fit-out sector and later led the interior architecture division, working on several hotel projects in London and abroad, as well as large scale housing developments.

(Kris@DDH) joined the architecture division of ---- as a Project Director in 2005 and was initially involved in the base build design and fit-out of Building 5 at Microsoft’s Reading Campus. Other projects included an award winning residential scheme in Croydon and a refurbishment Grade 2 listed buildings in Kensington. Promoted to Director in 2010 he has recently delivered a 500,000 sq ft mixed use masterplan in Staines and is currently working on student residential schemes in London and Cambridge.

(Kris@DDH) has a wide range of experience in dealing with complex buildings, and is skilled when working with clients and multi-disciplinary design groups to develop the most appropriate planning and design solutions. Committed to sustainable development and its integration in architecture he is an active member of the practice’s sustainable architecture group.”

Specific findings from Daniel Defoe Hall student interviews

- Controls: PIR only light controls in kitchen and living room
- Temperature: Air quality was ok but occupants sometimes mentioned it was getting too hot.
- Recycling: Do you as an architect have any say on how the accommodations should have the waste management and the recycling organized?

Before the interview:

- *Check the participants have read the information sheet that was provided*
- *Ask them if they have any questions about the study. If not, or when these questions have been addressed, invite the participants to read the consent form and if they are happy to do so to sign it*

Interview

Ok, thank you for that. Now, if you are ready we can begin the interview itself.

- 1. Could you tell me how you addressed environmental sustainability in Daniel Defoe Hall? How was ecological sustainability part of the design agenda?**
 - Is there something specific you apply for Student Accommodations?
- 2. Do you recall if it was a matter of discussion in the design process of Daniel Defoe Hall how the internal and external appearance of the building could message that it was a**

sustainable accommodation? Was there any attempt to use visual elements on the façade or in the interior that could signal the high sustainability profile of the building?

- Yes:
 - Could you tell a bit more about that?
- No:
 - What do you think why wasn't this aspect considered?
 - I'm asking this because some studies indicate that people tend to act more sustainably in buildings if they know the building is sustainable...

3. Thinking back at the design process of Daniel Defoe Hall do you recall if you received any kind of information on student needs or lifestyles and how design should support those needs and that lifestyle?

- Yes:
 - Could you tell a bit more about that?

4. Could you tell me how the indoor environmental quality (IEQ) was forecasted in Daniel Defoe Hall?

- Thermal comfort, natural and artificial light and air quality
 - How was the thermal environment of the rooms projected?
 - What was the idea behind the ventilation device on the windows?
 - How was the need for the light levels assessed?
- Was there any simulation involved? Could you tell me more about it?
- Could you tell me what stakeholders/team members were involved in projecting, defining, and validating the IEQ?

5. Do you remember how were the controls (system) considered? And when I am asking this, I am referring to how it was made sure that the systems and features fit the purpose, are easy to control, user friendly, intuitive so the operators and users will be able to correctly control the sustainable building and its appliances?

- Can you remember some examples around heating and cooling the spaces, ventilating, and airing the flats, natural and artificial light usage, water usage and recycling practices?
 - *Light controls in kitchen and living room area– how was it decided to use that specific form of controlling lights, the completely automated sensor-based lighting?*
- Could you tell me what stakeholders/team members were involved in projecting, defining, and validating the control systems or the user interface?

6. Do you remember if the project team considered any design elements or strategies to deliberately guide or drive pro-environmental behaviour?

(“For example: sticker for turning off lights, bathroom taps that turn off automatically, ground floor windows to allow in light without causing privacy issues, maybe using greenery in front of the rooms to ensure the privacy of residents, furniture arrangements of the room to ensure that there is no glare on the computer screens, using colours and textures to make the room brighter...”)

- Yes:
 - Could you please describe what those strategies were and how you used them?
 - How did you access information on these strategies?

- Could you tell me what stakeholders/team members were involved in identifying the strategies to apply?
- What do you think could help architects use more strategies to ensure pro-environmental behaviours?
 - For example, a handbook with visual information and explanations so designers could implement these easily in the design process?
 - Alternatively, some sort of trainings maybe?
- No:
 - Do you think architects would be interested in learning about techniques that support pro-environmental behaviour?
 - What do you think could make behaviour change techniques more accessible to architects?
 - For example, a handbook with visual information and explanations so designers could implement these easily in the design process?
 - Alternatively, some sort of trainings?
- Do you as an architect have any say on how the accommodations should have the waste management and the recycling organized?
 - If yes do you use any strategies in its design to encourage recycling?

7. What do you think what design innovations, concepts, technologies or strategies might work to better support or even enhance environmentally sustainable behaviour (ESB) in sustainable student accommodations (SSA)?

- Do you know about any existing behaviour focused design concept, design methodology, new technology or feature that could be considered and implemented in the design of SSA?
- Do you know of any other architectural or design practice that has applied strategies to enhance environmental efficiency of the designed building by stimulating occupants' behaviour?
 - Can you describe what were the approaches and how they were implemented in the design?
 - What do you think about these? How efficient do you think they are in practice?
 - Would you consider such an approach in your design? Why? Why not?
- Could you imagine any new design approach that could boost the efficiency of the future student accommodations by stimulating pro-environmental behaviour of the inhabitants? What are those approaches?

Ok, thank you for that. Now, let's talk a bit about the last phases of these projects. About handover and Post Occupancy Evaluations (POE)...

8. Do you recall how was the 'User guidance' and the 'As Constructed' document compiled for the end-users and operators of the buildings and what were the environmental sustainability related aspects of it?

- How were the users informed about the high sustainability commitment of the building and how to control the sustainability related features to ensure the environmental balance of the building?
- How was the operator/facility manager informed about the proper operation and usage of the building from a sustainability perspective?
- Was there any kind of training recommended for the facility manager on the operation of sophisticated features? (e.g. HVAC, CHP, biomass boiler)

- Do operators come back to you from time to time to learn about how certain features were designed to be used to ensure sustainability goals?

9. Do you happen to know if the building was evaluated In-use? Do you know if any POE/Building Performance Evaluations (BPE) has been performed on the building?

- Yes:
 - Do you remember what the environmentally significant outcomes were?
 - Do you remember how was the user satisfaction rated in the study?
 - Do you think the POE provided some good information that could be used in the future design of sustainable student accommodations? Could you tell me some of those features and how would you apply them?
 - Do you recall how was the building operator updated on the outcomes of the POE/BPE?
- No:
 - How helpful do you think POE/BPE studies would in providing information on actual building performance, on user satisfaction and how the space is used by the residents? How do you think the provided feedback could inform further design decisions?

Ok. These were all the questions that I wanted to discuss with you today. Would you like to add anything? Anything that comes in mind, about this topic we have been discussing?

Thank you for taking part in the study. Have a nice day!

General probes/prompts:

- *What makes you say that?*
- *Could you say a little more about that?*
- *I wonder if you could give me an example*

Mountain Halls - Architect Interview Schedule

Interview preparation:

Date: 03.11.2016 14:30-15:30

Location: Greyfriars House, Greyfriars Road, Cardiff. CF10 3AL

Participant pseudonym: Hanah

Architect background: Architectural Technician, BREEAM Assessor & Sustainability Advisor

Project type: Design and Build

Specific findings from Mountain Hall student interviews

- Privacy and light usage
- Glare effect on screens
- Controls: light in kitchen area
- Thermal comfort – spaces heating up, radiators very strong
- Long showers
- Recycling – bins in the rooms, waste outside was scattered around

Crome Court - Architect Interview Schedule

Interview preparation

Date: 10.11.2016 12:00-12:45

Location: Estates Building, University of East Anglia, Norwich

Participant pseudonym: Frank

Architect background: Partner

Crome Court summary from website:

- Used fully-integrated , '6D', BIM Level 2 in design phase.
 - 232 rooms
 - 5 to 7 storeys in a south-facing U-shaped configuration
 - only 98 weeks between starting design and completing the project
 - took ongoing costs, from facilities management and maintenance, into account in a new way
 - The building produces 95% less CO2 emissions than the same building under regulation standards, through high levels of insulation and renewables. Thermal insulation and air tightness are greater than current building regulations, and (against a 10% local planning requirement) 69% of the calculated energy use is provided by renewables (PV panels, biomass and gas CHP).
 - Environmentally, Crome Court is a low-impact building.
 - Cross-laminated timber (CLT) was used for the building's superstructure
 - Martin Lovatt, Project Manager, commented, "This building is a signpost, a figurehead of what can be achieved, but changing people's behaviour can have a much bigger impact in the longer term."
 - This is exemplified by the touch screen energy monitor in every kitchen, displaying the flat's energy use plotted as a percentage against the building's best and worst performing flats. We hope to engender a healthy level of competition that may help raise awareness of energy usage which students will take with them through their lives beyond the University.
 - Three-quarters of the showers from the building provide enough 'grey' water to flush all toilets in the building.
 - The project has raised the quality of design for student residences at UEA, demonstrated through feedback from a post-occupational review.
-

10.8. Architect interview analysis snippets

Table 44. Creating the Architect FNB table

	Feature	Need	Behaviour
1	Staircase	Availability Accessibility Ease of use Attractiveness	Stair use Less elevator use
2	Kitchen	Comfort Availability	Encourage meal preparation Reduce ordering food Reduce waste generation
3	Structural elements	Thermal comfort	
4	Cycle hub	Availability Attractiveness Ease of use	Cycling
	4	4 out of 4	3 out of 4

Table 45. Data-driven coding 1.

Transcript	Code/Theme
<i>"...as a practice because we've been doing student resis for quite some time, in fact we end up going and say these lectures or to participate very much in that... there is very little that we don't know about what the student's expectations..." "...and so we undertook a study"</i>	experience on student accommodations engagement in occupant studies deep understanding of occupant expectation
<i>"...it is accepted that students don't go and buy their bikes, they don't often make the financial commitment on that, they don't want to risk..."</i>	
<i>"...that rather than say simply provide endless racks of cycles on the assumption that students will come, in bring their own bikes or buy a bicycle and at the end of the academic year take their bikes with them ...you know that would be expected from students; but students rarely do that, students are not known to be going on and to buy the bikes and quite often let's say you have that spaces in the halls of residences full of cycle racks but maybe 20%, 30% says it is actually being used..."</i>	Knowledge of invalid assumptions The codes above were included into the higher-level theme of 'Knowledge and understanding of occupants' .

Table 46. Data-driven coding 2.

Transcript	Code/Theme
<i>"...and so we undertook a study with them to bring in these essentially free Brompton bikes which is quite unique from the rest of the university, because the rest of the universities where there is a BREEAM requirement, there are a number of cycles that you need to be provided for, there's also a planning criteria which is also set down to get permission for that many of cycles..."</i>	A more daring venture
<i>"...and it took quite a bit of persuasion to the planners as well as the BREEAM advisors, because the BREEAM does not accept to say, you know, this is sort of slightly different</i>	Recount of overcome barrier to design Barriers to novel designs

<p><i>venture to let's say a simple provision of cycle racks in terms of numbers to alternative means where, you know, you're encouraging cycles but not necessarily provide with the full facilities ...so the cycle racks..."</i></p>	<p>Solutions that enables not just allows cycling.</p> <p>The codes above were included into the higher-level theme of 'Knowledge and understanding of occupants' and 'Architects agency'.</p>
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10.9. Architect FNB tables

Table 47. Architect FNB Tables

Architect FNB Table

	Feature	Occupant Need	Behaviour
1	Building orientation	Comfort	-
2	Trees around the building	Aesthetics	-
3	Green wall	Recognisability	Raise awareness
4	Green spaces in courtyard	Recognisability Availability	Raise awareness Gardening
5	Cycle Hub with hanging bicycles, amenities and free bikes	Recognisability Availability Attractiveness Ease of use	Raise awareness Attract visitors Promote biking
6	Sustainable materials on facade	Recognisability	-
7	PVC panels	-	-
8	Exposed CLT	Recognisability Information	Raise awareness
9	Attractive staircase	Availability Attractiveness Ease of use	Increase staircase use Reduced reliance on elevators
10	Spacious kitchens	Availability Comfort	Encourage meal preparation Reduce ordering food Reduce waste generation
11	Energy information displays and meters	Information and Feedback	Reduce overall energy use
12	Window design	Recognisability Aesthetics Comfort Control Safety and security	Avoid having to close blinds and consequent use of artificial lights during the day Reduce reliance on artificial lights is taken for granted Prevent littering Prevent jumps
13	Long thin room layout	Comfort	-
14	Furniture arrangement	Comfort	-

15	Artificial light system	Availability Control Comfort Attractiveness	Reduced main light use Prevent forgetting lights on Reduce light use in living area
16	Low-flow taps with air bubble	Comfort	Reduce resource use
17	Ventilation	Comfort Attractiveness	-
18	Heat controls	Control	-
19	Acoustic insulation	Comfort	-
20	Control strategy overall	Ease of use	Avoid lack of use, misuse or damage
21	Waste management facilities	-	Promote recycling
		19 out of 21	13 out of 21

Kris FNB Table

	Feature	Occupant Need	Behaviour
1	Green spaces in courtyard	Recognisability Availability	Raise awareness Gardening
2	Cycle Hub with hanging bicycles, amenities and free bikes	Recognisability Availability Attractiveness Ease of use	Raise awareness Attract visitors Promote biking
3	Sustainable materials on facade	Recognisability	-
4	Attractive staircase	Availability Attractiveness Ease of use	Increase staircase use Reduced reliance on elevators
5	Spacious kitchens	Availability Comfort	Encourage meal preparation Reduce ordering food Reduce waste generation
6	Energy information displays and meters	Information and Feedback	Reduce overall energy use
7	Windows design	Recognisability Comfort Control Safety and security	Avoid having to close blinds and consequent use of artificial lights during the day Reduce reliance on artificial lights is taken for granted Prevent jumps

8	Artificial light system	Availability	Reduced main light use
		Control	Prevent forgetting lights on
		Comfort	Reduce light use in living area
		Attractiveness	
9	Ventilation	Comfort	-
		Attractiveness	
10	Control strategy overall	Ease of use	Prevent inappropriate use
		10 out of 10	8 out of 10

Frank FNB Table

	Feature	Occupant Need	Behaviour
1	Building orientation	Comfort	-
2	Trees around the building	Aesthetics	-
3	Green wall	Recognisability	Raise awareness
4	PVC panels	-	-
5	Exposed CLT	Recognisability	Raise awareness
		Information	
6	Windows design	Comfort	Reduce light use
		Aesthetics	
7	Low energy light fittings	-	-
8	Energy information displays	Information and Feedback	Reduce energy use
9	Low-flow taps with air bubble	Comfort	Reduce resource use
10	Natural Ventilation	-	-
11	Acoustic insulation	Comfort	-
12	Prominent bins	-	Promote recycling
		8 out of 12	6 out of 12

Hannah FNB Table

	Feature	Occupant Need	Behaviour
1	Windows design	Safety	Prevent littering
		Comfort	
2	Long thin room layout	Comfort	-
3	Furniture arrangement	Comfort	-
4	Light system	Comfort	-

5	Individual metering and paying utility bills	Information and Feedback	To make occupants pay attention to their consumption Reduced resource use
6	Heat controls	Control	-
7	Acoustic insulation	Comfort	-
8	Waste bins and their spatial arrangements	-	-
9	Control strategy overall	Ease of use	Avoid lack of use, misuse or damage
		8 out of 9	3 out of 9