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Experience Centered Design of Energy Interventions for Shared Student Accommodation

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ABSTRACT

Delivering effective interventions to motivate people living in shared, pre-paid rented accommodation to reduce their energy consumption is a well-recognized challenge, since there are no financial incentives for people to engage with such efforts. This paper reports on the experience centred design of digital energy interventions for shared student accommodation, led by 100 participant researchers (all students of an undergraduate HCI module), who themselves recruited approximately 300 participants to engage in interviews and design tasks. The research method was informed by principles of participatory design and practitioner-led inquiry, with the intention of eliciting practical, reflective, experiential data to inform the design process. A thematic analysis was carried out to identify clusters of experiences, perceptions, attitudes, behaviours, challenges, and opportunities identified by participant researchers. Findings emphasise the complex social and personal experience of students in interacting with energy consuming devices, and illustrates the value of engaging with these issues at an experiential level.

Author Keywords

Sustainability, persuasive, experience centered design

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI)

INTRODUCTION

The design of technology that facilitates and promotes more environmentally sustainable behaviour has become a major area of focus for the HCI research community [9]. Much recent research explores the possibility of motivating and facilitating end users to make behavioural changes in their use of energy, through the development of digital interventions that allow participants to more easily understand and track their energy consumption. However, there is little evidence of these developments bringing about sustained long-term change in energy consumption behaviour, and little coherence between the conceptual and methodological approaches underlying such work more generally [9]. In order to better inform the design process, this paper eschews further theory building, and instead presents a collage describing the breadth and depth of experiences that participants identify as relevant.

In the following sections, we first present a review of previous work on the design of technology-led energy interventions, focusing specifically on interventions for shared student accommodation. Experience centered design is introduced as a means for understanding the complex social and personal factors that may affect student engagement with energy reductions, while the methods of participatory design and practitioner-based inquiry are discussed as a means for eliciting and understanding participant experience in this context. A thematic analysis of data collected and reflected upon by 100 participant researchers is then presented. We finally discuss the implications of this data for the future design of interactive digital, or indeed non-digital, interventions to motivate more environmentally sustainable behavior in shared pre-paid accommodation.

BACKGROUND

Technology led energy interventions

Research suggests that people typically have a poor understanding of their electricity consumption, since such consumption is invisible, often obfuscated, and difficult to understand [1,4,20]. However, due to the recent proliferation of smart meter infrastructure, it is now possible to develop digital systems that expose energy consumption, and provide interpretive feedback, to users. Thus, the design of technology to help users make behaviour-based reductions in their energy consumption has received a great deal of attention in recent years by the HCI, ubicomp and related communities (i.e., [4,13,5,7]). Furthermore, decades worth of studies carried out by environmental psychologists have demonstrated that providing people with direct, intuitive feedback on their energy use can motivate them to reduce consumption (see [4,9] for reviews). Previous interaction design work has delivered feedback through interfaces such as phone applications [22], ambient displays [12], and social networking sites [7].

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Energy interventions in shared student accommodation

HCI research into the design of energy feedback systems tends to focus on applications in either the domestic [5] or organizational [8] setting. Different challenges have emerged from these environments; for example, people are unwilling to sacrifice hygiene or comfort related behaviours at home, and report a lack of responsibility for consumption at work. Interestingly, shared student accommodation appears to offer a combination of the challenges of those contexts; student accommodation is a student's home, but due to electricity being charged at a 'flat' pre-paid rate, there are no financial consequences of saving, or indeed wasting, electricity [17]. Indeed, student energy related behaviour has been identified as an issue of significant concern, as evidenced by various campaigns to promote more ecologically responsible behaviour, such as the "student switch off" (http://www.studentswitchoff.org/) campaign in the UK.

A limited amount of previous HCI research has investigated the design of energy interventions in shared student accommodation. For example, Odom et al., [17] evaluated a feedback interface that facilitated competition between separate dormitory buildings, concluding that social incentives proved more motivating to students than environmental concerns. [1] identified variations in energy usage across students, suggesting that targeting the behaviour of a small number of abnormally high consumption students could facilitate significant savings.

The theory-practice gap

Regardless of the context in which they have been implemented, or the design strategy adopted, there are very few examples in the HCI literature of technology-led interventions either sustaining user engagement or, more importantly, facilitating long-term reductions in energy usage [5,9]. Some researchers (i.e., [8,9,13]) have suggested that the failure of these systems are due to a lack of understanding on the part of designers of the complex ways electricity usage fits within and impacts peoples lived experience. In this respect, there appears to be a disconnection between how technology mediated behaviour change works in theory and in practice (see [19] for a parallel discussion of theory practice gap in social science).

The initial stages of design of energy interventions often involve social science-style research on small groups of potential users, in order to build and adapt "theories" of energy usage. Prototype systems are then built to implement those abstracted concepts. Interestingly, the practice of abstracting data gathered in small-scale user studies to form theories that inform a design process has been much criticized recently. For example, Ghassan & Blythe [11] suggest that this approach is symptomatic of researchers not discriminating the "minor science" of design practitioners with the "royal science" of basic researchers. Gaver, et al., [10] criticise the scientific analysis of user data as blunting the connection between designer and user. Similarly, Olivier and Wallace [18] argue that reducing users' experiences to a set of objective data can diminish our understanding, and subsequent valuing, of human heterogeneity. In our work we intend not to build solutions based on abstracted theories, but through contact with the unfiltered experiences and reflections of participants. Indeed, in the context of designing technology that we expect to impact significantly upon people's lives, it seems especially important to engage with participants at an experiential level [20].

Experience-centered design

In recent years, computing technology has developed from something primarily used in organizations to facilitate commerce, to something that impacts upon all aspects of our personal, social and cultural lives [22, 23]. The study of human interaction with computers has moved away from analyses of human cognitive abilities and interface usability, and towards a more holistic understanding of the complex interactions between technology and the human experience [6]. The process of designing technology based on understanding the subjective experiences of users is referred to as experience centered design [23].

Unsurprisingly, there is little agreement on how best to understand the experiences of people as part of the design process. For example, Forlizzi and Ford [6] proposed *subconscious, cognition, narrative,* and *storytelling* as useful analytical dimensions. Wright and McCarthy [22] identified *emotional, sensual, compositional* and *spatio-temporal* as components of experience. Norman [15] breaks experience into *visceral, behavioural* and *reflective*. Despite this lack of consensus, there does seem to be an overall commitment to understanding interaction from a holistic rather than reductive perspective [2].

In addition to the lack of philosophical consensus, there is also no agreed-upon best-practice research method for sampling experience as part of the design process. However, Wright and McCarthy [23] emphasise that the most fundamental requirement is a commitment to dialogue between designers, users and communities. Hence, research methods drawn from the social sciences seem most appropriate. We have identified two research methods that seem useful for understanding participant experience in the context of the current paper, described below.

Participatory design

Participatory design is a process long established in both research and industry. It is an approach that invites the people who will benefit from, or be impacted by, a technology to participate in its design, with the intention of empowering those communities. There is also an assumption that involving participants in the design process should lead to more acceptable, useable and useful technology [21,23]. The practical act of creating solutions to design challenges can also be seen as a means for eliciting more realistic contributions from participants than is possible with interviews and focus groups, which often produce vague, or unrealistic results, or suffer from effects of social acceptability. Further, due to the potentially intrusive nature of energy interventions we feel compelled to adopt a participatory approach to our design work.

Practitioner based inquiry

Practitioner based inquiry is a method not commonly used in HCI research, but one which seems to offer value in

sampling and understanding the experience of participants. It is most commonly employed by practitioners such as nurses [19] and educators [14] in investigating and reflecting on their own practice. Since people who generally have minimal training in research methodology carry it out, the method remains controversial and divisive. It is seen by some as entirely unscientific, on a par with spirituality and witchcraft [14], and by others as the necessary process through which subjective experiences can be understood, and theory can be put into practice [19].

There are parallels between the goals of experience centered design and practitioner-based inquiry; both emphasise pragmatism, subjectivity and experience as necessary and valuable (see [19]). It follows that there may be some value in carrying out experience centered design through a manner influenced by practitioner-based inquiry. Specifically, rather than eliciting requirements from participants through interviews, focus groups and design tasks, it may be useful to encourage participants themselves to undertake this research. There are many advantages to this approach. For example, in line with the motivations for participatory design, the people who will be affected by the technology (i.e., students) are empowered to influence its design. However, in the study presented in this paper, participants are not only empowered through being consulted, or collaborated with, but they fundamentally define the very questions that are asked. Thus, in line with practitioner-based inquiry, the narrative generated from research is inherently and entirely composed of the practical lived experience of participants. We feel entirely justified in conceiving of students as 'practitioners' in this context, since their own experience, and that of their peers, is exactly the experience they are researching, and that we are interested in. Additionally, the fact that research is planned and carried out by peer accomplices rather than professional researchers reduces the likelihood of sampling invalid socially acceptable pro-environment opinions. In addition, we feel that carrying out research in such close collaboration with students [15] is a uniquely productive approach to teaching and learning HCI at undergraduate level, and one capable of generating publications for tutors.

The disadvantage of the approach is that it does not allow for the generation of a coherent, generalisable theory of energy usage in student accommodation. It therefore suffers from the same criticisms leveled at wider practitioner-based inquiry (see [14]). However, the intention of the study is not to build a scientifically accurate theory, but to inform design through building a collage from the breadth and depth of experiences that participants tell us are relevant in this context. The advantage of the large sample is in the range and breadth of experiences elicited.

METHOD

Participants

One hundred and three people (ten female) were recruited from an undergraduate HCI module to act as participant researchers (hereafter referred to as researchers). Three of those failed to return any usable data, leaving exactly 100 researchers in the final sample. Those researchers themselves each recruited between two and five participants (hereafter referred to as participants), giving an approximate (due to sometimes vague reporting) participant sample of 300. Importantly, all participants and researchers had some personal experience of shared student accommodation.

Procedure

Researchers engaged in experience centered design activities concurrently with their study of the HCI curriculum. They were initially presented with a design challenge, and used experience centered practices to understand and address that challenge. Researchers initially conducted focus groups in order to elicit requirements. They were given the freedom to employ a variety of techniques within those focus groups. The majority (n=53) employed semi-structured interviews, but questionnaires (n=40), card sorting (n=26), participatory design tasks (n=15), diary studies (n=13), cultural probes (n=4), and "cool walls" (n=4) were also used, and some researchers used more than one technique. Each researcher produced a thematic analysis of their focus group data. Finally, researchers produced a paper-prototype based on the findings of their research. Due to both space restrictions and the focus of this paper we do not present the results of the paper-prototyping task.

Data Analysis

Each of the 100 researchers inductively identified three themes in their focus group data, which they commented on and justified with quotes, typically constituting one paragraph of text per theme. The authors of the current paper took the text produced by those 100 researchers and carried out an inductive thematic analysis. Thus, the data presented here represents both the subjective, experiential information from participants, plus the researchers' reflections on, and interpretations of, that data. It should be stressed that, since the researchers were, themselves, members of the participant group, their own reflections are valid experiential data. Moreover, since researchers had spent time researching and considering the topic, we would assume that their reflections would be better informed and more useful for the purposes of design than that of a naïve participant.

An inductive thematic analysis was carried out on the data obtained from researchers following the method outlined in [3]. Thematic analysis is useful for analysing large quantities of qualitative data, especially in little understood domains where existing theories and models do not exist. Data was first transposed into a spreadsheet and separated out with one sentence per row. Thus, the unit of analysis was at the sentence level. In total, 1,760 of these units were analysed. Open coding was carried out first. Specifically, a researcher read the data closely, attaching a conceptual label (or 'code') to each line of data. A total of 87 codes were generated, which were then grouped together based on conceptual similarity, creating 34 learned abstracted categories. Axial coding was then carried out and abstract categories from open coding were amalgamated to create more defined clusters, referred to below as categories.

Theme	N
Student experience	146
Activities	53
Consumption	53
Defining Coolness	40
Energy consumption	232
Living arrangements	15
Listing devices	26
Essential usage	37
Non-essential usage	30
Wasting electricity	80
Environmental impact	20
Wanting to reduce	24
Barriers to saving	291
Lack of understanding	23
Awareness	77
Economic consequences	67
Forgetfulness	12
Laziness	7
Motivation	42
Comfort and convenience	11
Apathy	52
Behavioural Solutions	209
Lifestyle changes	12
Rewards	73
Punishment	17
Competition	77
Cooperation	30
Design suggestions	450
Platform	74
Simplicity	29
Visualisation	112
Functionality	129
Visual Appearance	56
Privacy Concerns	35
Extravagant requirements	15
Describing approach	26
Linking sentences	322
Unintelligible	84
Total	1760

Table 1. Descriptive analysis of number of occurrences of themes identified in the data.

RESULTS AND DISCUSSION

Five distinct categories were identified, based on the type of information that participant researchers were trying to learn through their research. These categories are; *Understanding Student Experience, Understanding Students Experience with Energy, Barriers to Reducing Consumption, Suggested Behavioural Solutions*, and *Design Suggestions*. A descriptive analysis of the relative occurrences of each theme identified is presented in Table 1. The categories are expanded upon below, with unique themes identified within each category. We have attempted, as much as possible, to tell the story in the words of the researchers themselves.

Category 1: Understanding Student Experience

These data (146 mentions) represent researchers attempts at gaining a general understanding of the subjective experience of undergraduate students living in shared accommodation. Due to space requirements, and in order to focus on experiences more specifically related to their electricity consumption, we have kept discussion of this category to a minimum. Participants in our study reported enjoyment of socialising, drinking alcohol, playing computer games and using social media. However, one finding that does seem potentially useful is that researchers consistently described the student lifestyle as inherently social, and suggests that the attitudes of others, and what they consider cool, can influence their own attitudes and behaviour.

Category 2: Understanding Students Experience of Energy

Data classified in this category (232 mentions) represents researchers' attempts at understanding student's attitudes towards, and experiences of, using electricity in their day-to-day lives. Seven distinct themes were identified in the data; *Describing Living Arrangements, Listing Devices, Essential Usage, Non-essential Usage, Wasting Electricity, Environmental Impact,* and *Wanting to Reduce Consumption*. *Describing Living Arrangements*, focused on understanding how distinct patterns of consumption can be seen within a flat; *"With each student spending the majority of time in their rooms…. each room will have electrical appliances/devices turned on, on standby or charging up"* (P32), *"my bedroom because it's got most of the technology in it"* (P43), *"On the opposite, the energy in the kitchen is used by all flatmates"* (P2). Indeed, across all the data gathered, it seems evident that, *"most of the time the students are at home…. some kind of technology is always being used"* (P80). Some researchers chose to focus on listing the types of devices that students used in their accommodation, *"it appears most students use a variety of devices on a regular basis"* (P84), *"The devices in a student house can build up to about 30"* (P89). These ranged from kitchen appliances *"kettle, cooker, oven, microwave, iron and refrigerator"* (P2), *to "TV, games console, laptop"* (P43) to *"Xbox, DVD Player and I-pads"* (P92) and *"smart phones"* (76). Very little of this data is surprising or unique to students.

Some researchers concentrated on distinguishing *Essential Usage* (i.e., usage that participants would be unwilling to reduce) from *Non-Essential Usage* (i.e., usage that could be potentially targeted by intervention). However, there was little consensus across researchers as to which types of usage fell into each of those categories, *"what is seen as essential differs from person to person"* (P53). As expected, researchers found that a large number of students consider energy usage related to cooking and cleaning to be essential, *"they tend to prioritise more essential kitchen and bathroom items required for everyday life over leisure and entertainment"* (P6), *"all of the students will use the kitchen*

ware for example kettle and microwave," (P35), *"Heating and Lighting"* (P53), "*one said he found the shower essential whilst the other said he found the shower non-essential"* (P53). Further researchers found that students consider energy consumption related their studies to be essential; *"they needed it to do their work,"* (P13), *"computer and laptops being a necessity for a university student due to the amounts of research and work needed,"* (P32), *"they use energy as part of their education"* (45). Interestingly, the majority of students reported that the use of electricity for entertainment purposes was also essential, *"no motivation would stop him from interacting with the devices he uses for social computing,"* (P4), *"Students said their PC's were so important because "I need it for socialising, video games and movies"* (P56), *"I live a rather busy lifestyle so mainly things like TV, computer, games console, things like that"* (P43). Given that many *"participants were not willing to change their behaviours or hobbies in order to save energy"* (P13), it is difficult to see where savings in energy consumption can be achieved.

A small number of researchers suggested *Non-Essential* uses of electricity; *"energy that was used for entertainment purpose,"* (P4), *"participants find the entertainment items less importance"* (P6). While this finding is interesting, it is in direct contradiction with that discussed above. Some researchers suggested that savings could be made in the usage of devices simultaneously, "*Using a device as background noise is an unnecessary use of energy"* (P32), *"Participant 4 admitted to "listening to music whilst playing on" his "games console and cooking food as well"* (P40). Perhaps this type of simultaneous usage might be the best target for intervention. Surprisingly, one researcher also found that; *they were happy to give up with such devices as: cooker, oven and hairdryer* (P2), *they would use less ironing, keeping light off and using less heating* (P2).

A number of researchers described their participant's behaviour as *Wasting Electricity.* Participants often leave electrical devices turned on regardless of whether they were being used or not. This ranged from lights; *"both students leave lights on unnecessarily"* (P36), *"Two of the students claimed that they could not sleep without the use of a night light"* (P30), to computers, games consoles and televisions, *"evidence in the research of computers being left on"* (P11) *"they left appliance's on such as their laptops and phones chargers, also including leaving their television on standby"* (P15), *"Participant 1 admitted to using his "phone, iMac, games console, lighting, speakers and headset" at one given time"* (P30). Participants also discussed mis-use of charging, *"My worst habit is having my laptop on charge constantly"* (P27), *"Participants stated they charged devices at least daily"* (P7). The observed tendency to leave devices turned on seems to be driven by convenience and comfort, *"they do this because it saves on time"* (P15),*"participants agreed that they thought it was pointless to turn off their devices because they would use it again some time in the short future"* (P52), *"I put my laptop on sleep because I can just open it up and continue what I'm doing instead of having to boot it up"* (P66), *"students cited their hectic schedules as a key influence in their use of technology"* (P43). Beyond convenience, some researchers reported examples of extravagant usage, *"Participant 3 admitted to using her hair straighteners more than once daily, after lectures at University she would "go home, get something to eat and then straighten" her "hair again to make sure that" she "looked nice*" (P30). *"One participant told me that instead of getting his window fixed he just turned his heating on more often*" (P72), *"Participant A mentioning how they enjoyed the warmth of the heating, but also the fresh air – resulting in heating being pumped into the cold winter air"* (P98), *"Have you ever left the window open and the radiator on? "Er yeah it's the best way to do it"* (P11). In summary, since so much energy seems to be wasted in shared student accommodation, there is great potential for reducing energy consumption through targeting these wasteful behaviours. However, a significant challenge exists, as students feel justified in engaging in these wasteful behaviours, as they aid in their comfort and convenience.

Very little of the data gathered made any mention of the *Environmental Impact* of using electricity. There were some instances where researchers reported positive attitudes towards the environment, *"it helps save the planet so that is something I would consider as cool"* (P48), *"One participant was very passionate that reasons to reduce energy are to reduce impact on nature"* (P77). However, the majority of attitudes expressed towards the environment displayed a lack of interest and responsibility, *"students from the focus groups require convenience over things such as impacts over the environment"* (P50), *"…the amount of electricity we use isn't going to contribute anything to like the overall effect of global warming, so that sort of stuff doesn't really bother me"* (P52), *"All cards relating to climate change considered lame on the cool board"* (P57), *"they care more about money than the environment"* (P12).

Some researchers found evidence of participants *Wanting to Reduce Consumption*; *"all of the students want to reduce their energy used"* (P35), *"both participants thought that energy saving is cool"* (P48), *"all the participants think that reducing energy usage is "quite important"* (P60), *"most students are somewhat conscious to saving energy by turning off devices"* (P84). However, this view was not unanimous, and indeed, there were contrary views expressed; *"people that are most interested in being energy aware are fanatical liberals who protest all the time"* (P11), *"My fear is that this wouldn't increase how much energy they are saving as one of the subjects said that even if they knew their usage it wouldn't stop them from being wasteful"* (P101). There are clearly significant challenges to any intervention intended to persuade students to reduce their energy consumption.

Category 3: Barriers to Reducing Consumption

These data (291 mentions) represent researchers' attempts at understanding student's perceptions of the barriers to reducing their energy consumption. Eight distinct themes were identified in the data; *Lack of Understanding, Awareness, Lack of Economic Consequences, Forgetfulness, Laziness*, *Motivation, Comfort and Convenience, and Apathy.* Reflecting the findings of previous studies [4], a number of researchers found that participants expressed a *Lack of Understanding* regarding their energy usage; *"students may not be too familiar with existing terminology or whether their current energy consumption level is*

particularly high or low" (P43) *"there is not a defined scale of how much I should and shouldn't be using"* (P81). One participant suggests that, *"if they were better educated in this area, they would feel more conscious on their energy usage"* (P97). It is clear that there is a problem with the students understanding of energy consumption, and that education may play some role in any intervention developed.

A related issue is the awareness of their own behaviour. Researchers found that participants consistently expressed a lack of awareness of their own *Level of Consumption, the Relative Consumption of Devices,* and of *How to Reduce Consumption. "All three participants said they are not aware on how much energy they use"* (P12), *"they did not get any feedback from the company they are with"* (P15), *"There is no meaningful data accessible to students"* (P22) *"there is no way I can find this information out in my house"* (P36). Discussing Relative Consumption; *"they, usually, do not know how much energy they use by each device"* (P2), *"weren't aware of what items used up how much energy"* (P59),*"We always leave the TV on because we forget, so it'd be interesting to know how much energy that's actually using"* (P52). It seems clear that students living in shared accommodation rarely know how much energy they are using, and that this may contribute to overconsumption.

One of the most consistent themes running throughout the data is the impact that a *Lack of Economic Consequences* has on participants' behaviour. *"Students don't take notice of wasted energy if there is no consequence"* (P56), *"I pay a 'flat rate' which doesn't change whether I'm saving energy or not"* (P4), *"there is no financial incentive to save electricity"* (P17), *"As I do not pay for energy bills, I do not care"* (P37). Interestingly, paying a flat rate for electricity, seems to actually encourage irresponsible over-consumption from students; *"the fact that we don't have to pay just makes us like 'meh, we might as well make the most of it'"* (P52), *"as they already paid for it they might as well use it"* (P76). This is a psychologically significant unintended consequence of the traditional pricing policy for shared student accommodation. Undermining this attitude through technological intervention may prove a difficult task. Indeed, students suggestions for interventions typically involved the imposing of economic consequences, *"if there was a possible money benefit from saving energy then it would be seen as more appealing to students"* (P4), *"if I had to pay for the bills then I would try and use less"* (P48), *"they care more about money than the environment"* (P12), *"I save energy to save money, not the planet"* (P45).

A small number of references were made to *Forgetfulness, Laziness*, a general lack of *Motivation, and Comfort and Convenience* as barriers to reducing energy consumption. *"They often had trouble remembering to turn things off"* (P40), *"the light switch, you always forget to switch if off when you're not in the room"* (P52), *"Some people want to save energy, but simply forget to switch off plugs and devices"* (P94). There may be some advantages in targeting this forgetfulness with an intervention, perhaps with reminders, but it was mentioned as an issue by only a small number of participants. There was also mention of laziness as a barrier to reduction, *"I want my applications to be there when I start my laptop up' which implies some laziness as well as efficiency"* (P58), *"I think it also comes down to laziness"* (P66). Researchers also identified a general lack of motivation on the part of students to reduce their consumption; *"at the moment there is no motivation to use less energy"* (P52), *"one of the main reason why they didn't monitor the current power usage was because they had not motivation or encouragement to do it"* (P95). Echoing a theme identified earlier, many researchers identified *Comfort and Convenience* as barriers to students behaviour change; *"participants are unwilling to change their hobbies just to save energy"* (P53), *"any energy intervention cannot interfere with their personal comfort"* (P98), *"convenience appears to also be a key factor in the student's choices"* (P83).

One striking theme that emerged consistently from the data was that of *Apathy*. Participants consistently reported a lack of interest in their use of electricity; *"Most of the interviewee's did not consider energy usage a concern of theirs"* (P23), *"they didn't think about they're electricity usage very much at all"* (P17),*"Even though I realise it is an issue, it has never been imposed on me culturally"* (P37), *"the topic of energy is quite boring*" (P89) *"it was a general lack of interest"* (P101), *"participants said that they did not actively think about their energy usage"* (P61),*"none of the people questioned, are actually interested in the information regarding their energy consumption"* (P47), *"participant one has no interest in the consequences of their actions"* (P52). Besides a general lack of interest in their use of electricity, there was also a specific lack of interest in reducing their consumption. *"I do not make a conscious effort to reduce my energy consumption"* (P81) *"He also admitted that this usage could be lowered but saw no benefit in lowering it"* (P30), *"YOLO"* (P8), *"not being entirely concerned about the effects of their usage resulted in them using more energy than necessary*" (P52), *"even though users may know they use too much energy they may not be willing to make changes"* (P45). These data outline a very difficult challenge for the designers of persuasive interventions. The prevailing opinion towards reducing energy consumption is a lack of interest and a lack of responsibility, reflecting the findings of [20]. The most striking aspect of these data is the honesty of responses, despite the fact that the attitudes expressed could be considered socially inappropriate.

Given all of the challenges identified to creating successful energy interventions for shared student accommodation, it is essential to now examine the suggestions provided by participants for potential solutions to this problem.

Category 4: Suggested Behavioural Solutions

These data (209 mentions) represent researchers' attempts to understand student's perceptions of interventions that may be effective in engaging students in reducing their energy consumption. Five distinct themes were identified in the data; *Lifestyle Changes, Rewards, Punishment, Competition, and Cooperation.* Some researchers identified *Lifestyle Changes* that participants expressed as acceptable; *"going out for football, gym, swimming or walking would cause in saving energy, because no one will use laptop, lights and so on"* (P2), *"I will turn off my light when I am sleeping and out of the room then I will not charge the*

laptop all day" (P35). Suggestions such as these represent a tiny percentage of the total data, and given the evident lack of interest expressed by the majority of participants in saving electricity, they seem unlikely to be followed long term by a significant number of students.

Much more evident in the data was a wish from students for more obvious consequences of their energy consumption. Participants consistently identified the provision of *Rewards* as an attractive component of any intervention; *"a reward would make them motivated if involved with the saving of energy"* (P15) *"the need for students to feel that they are being rewarded for the time that they put into something"* (P84) *"being rewarded was a key part to engage the end-user"* (P85). Suggestions were also made of how a reward system could work in practice; *"A reward system whereby at the end of each month, the person who saved the most is rewarded"* (P102), *"rewards the user each time energy is saved when they manage to use it less"* (P6), *"A reward for the group or individual who has used least energy"* (P39). As a note of caution, however, one researcher identified, *"both of them were interested in the size of the reward in relation to the amount of effort they must carry out"* (P58). Some researchers identified the possibility of using virtual rewards, *"the app should include an achievement system similar to games consoles"* (P16), *"awarding points for a user reducing energy consumption which could then be used in-game"* (P33). However, the majority of participants who suggested the use of rewards as motivators preferred tangible incentives, *"Perhaps like, Amazon Vouchers for winners or something like that"* (P5), *"monetary rewards"* (P19), *"this reward was beer"* (P15), *"free gig tickets and downloads"* (P52), *"alcohol, vouchers, Facebook points"* (P59), *"£50 to everyone in the flat that saves the most energy…"* (P66), *"Err, free food, free drink, and money"* (P77). Interestingly, *Punishment* was identified by a small number of researchers as a useful means of motivating reductions in energy consumption, although the suggestions were quite vague; *"punishment would also encourage them to save energy"* (P87), *"I should create something social so that very wasteful people would be shamed in front of their friends"* (P101), *"making someone feel bad without restricting them physically or in reality is the way to go"* (P40).

The most commonly suggested means for motivating reductions in energy consumption was through *Competition*; *"the student demographic liked the idea of competing"* (P97) *"the best way of making people change their behaviour is to turn it into a competition"* (P16) *"The importance of competition is highlighted throughout all the sections of data collection"* (P42), *"giving the victory "energy bragging rights" was a phrased that was used in the focus group"* (P70). There were suggestions of how the competition could be facilitated in practice; *"maybe an inter-apartment competition"* (P10), *"groups competing against each other"* (P51), *"leader boards to publish your results to social networking sites"* (P79).

Researchers also found that participants suggested *Cooperation* as a technique to motivate students to reduce their energy consumption; "*It is clear that if some students started to save electricity it would encourage others as well… All participants agreed that such an environment where everyone is trying to consume less energy would push them to stop wasting it"* (P2), *"the behaviour of their flatmates influenced them, even against their own principles and highly held standards"* (P98), *"the importance of the application being inherently socially cohesive rather than competitive or divisive"* (P19), *"participants rejected individual competition in favour of a group-based activity"* (P98).

In summary, researchers have identified some very practical suggestions for motivating students to reduce their energy consumption. These all focus on providing consequences for behaviour, through either direct rewards or punishment, or through a larger social intervention involving competition and/or cooperation between students and reflect previous findings in the field (i.e. 17).

Category 5: Design Suggestions

These data (450 mentions) represent suggestions made by participants, and reflections by researchers, on the design of energy interventions. Seven distinct themes were identified in the data; *Platform, Simplicity, Visualisation, Functionality, Visual Appearance, Privacy Concerns*, and *Extravagant Requirements*. Most researchers gave some indication of the platform their participants indicated as appropriate for engaging with the intervention. Mobile devices were the most commonly mentioned platform, followed closely by laptops and personal computers; *"an app that can go on mobile phones"* (P14), "*they all wanted a mobile application"* (P38), *"it's got to be the laptop yep definitely"* (P3), *"phones, personal computers and laptops,"* (P29). Others emphasized the importance of an interface that is available across multiple platforms, thus allowing students to use their existing devices, *"it should be available multiplatform in order to allow access at any time"* (P83), "*The idea of using special device for observation of using energy was met negatively"* (P2), *"easily integrated with the gadgetry students use more regularly….. as opposed to brand new, stand-alone technology"* (P29). The last comment is interesting, since the established trend in household energy monitoring has largely focused on physical in-home devices. Researchers also identified that participants were attracted to *Simplicity* in design, and this was a consistently recurring theme in the data, *"simplicity appeared as a recurring theme in the design"* (P43), *"the users wanted a simplistic interface and didn't require a lot of time or effort"* (P85).

Researchers frequently reported on discussions of energy data *Visualisation.* They discussed the importance of using visualisations to help interpret the data for users*; "I don't think they will understand, if you show a lot of information"* (P28), *"would prefer it to be shown in a way they instantly understand"* (P31), *"the importance of clear, easy to read feedback"* (P73). Remarkably few suggestions were given for implementing those simple visualizations, but there was some discussion, *"simple bar graphs or pie charts"* (P88), *"The use of metaphors to represent the amount of energy saved"* (P42), *"having the object change colour"* (P31), *"No one remembers figures…..I'd remember the guy getting to the top of the steps"* (P77). Researchers identified that students often expressed an interest in seeing the

consumption of individual appliances, *"ability to show the different electrical appliances so you can monitor them"* (P1), *"Comparing data on usage by device"* (P29), *"lots of detailed information about specific appliances"* (P53). Participants requested the ability to visualize expenditure, *"how much the energy is actually costing you",* (P5), *"giving a cash value to saving of energy"* (P7), to track progress over time, *"what would help them improve is seeing they're own 'self-improvement"* (P16), *"Recognition of progress"* (P20). Researchers identified that students valued the ability to see these data in real time, *"what people want to be able to do is walk around their flat and be able turn things off, and see the statistics change"* (P16), *"I would love a big board with lots of numbers moving around in real time. That'd be awesome"* (P77).

Researchers discussed the types of *Functionality* that participants reported as appealing. A number of researchers identified notifications and reminders as possible solutions, *"something which reminds you often"* (P18), *"A reminder to turn something off if you leave the room …. But without being annoying or nagging"* (P40), *"It could alert me half way through the day of how much energy I have used"* (P81). However, the dangers of such an approach were also discussed, *"the idea of a device telling someone to turn things off, was rather a troublesome subject…. If something explicitly tells me to do something I kind of resent it"* (P40). Researchers identified as important the integration of social features in any technological solution, *"should incorporate the major social networks into any design to encourage interactions between students"* (P83), "*a need for users to be able to communicate and share their results with others, for either competitive or cooperative/encouragement reasons"* (P45), *"those who are saving a lots friends will glorify them"* (P101). However, disadvantages of including social functions were also raised; *"Although this is a good idea one of the disadvantages could be that there may be rebellious students who want to boast how much energy they can use"* (P82). A number of researchers mentioned the wish for some form of automation or remote control as part of the intervention, *"one participant wants the app to be able to turn the heating on or off"* (P38), *"a push of a button can switch it all off"* (P14), *"a method of turning a light bulb off without them interacting with it"* (P87).

Interestingly, while participants seemed to want social features and interfaces that are accessible online across multiple platforms, they also expressed *Privacy Concerns*; *"the lack of privacy…was a great enough concern for the participants to not post sensitive data onto Facebook"* (P55), *"they wanted to be able to see friends' energy usage and vice-versa but not have anyone else be able to see their usage"* (P70), *"they would like to have a choice to share or not"* (P2). Interestingly, one researcher found that, *"it is important that students can activate and deactivate their energy tracking at any given time"* (P88). This concern, if implemented, would clearly undermine the accuracy and efficacy of any of the interventions based on feedback or providing consequences.

Researchers noted that participants often referred to the *Visual Appearance* of potential energy reduction technology. There was frequent that the final design, *"should look 'Cool'"* (P25), *"If the object is ugly it will not be used"* (P31),*"bright colours"* (P20). Indeed, many researchers expressed favour towards, *"a traffic light system, red meaning they are doing very bad, green meaning there are saving money and yellow being normal"* (P38). There were also quite a number of *Extravagant Requirements* expressed, ones which seem too vague too be realistically implemented given our current understanding of technology development; *"I think the summary of it all is it has to be something different each time to keep you interested….Monday it's this type of design. Every Tuesday it's something else"* (P55).

Design Implications

Given the breadth of challenges raised in these data, it seems unrealistic to think that a simple technology solution can have significant effects on the behaviour of students living in shared accommodation. The problem is clearly complex, which provides some explanation for the relative lack of success of technology-led energy interventions, which are typically designed based on simplified conceptions of behaviour. Any successful intervention must engage with and address precisely the types of issues raised in this paper.

Particularly challenging is the observed attitude that convenience, comfort and enjoyment seem to take precedence over any other concern, and that saving the environment is considered particularly lame (reflecting [1,17,20]). Moreover, there is a lack of willingness on the part of participants to accept responsibility for their own actions, as reported so succinctly by P52, *"participant one has no interest in the consequences of their actions."* The development of feedback technology is justified by the assertion that people are unaware of their own usage, and that feedback in itself should help people control and reduce their consumption [4,9]. This rather positive assumption was reflected by many participants and researchers in the data presented here. However, there was also a thread of critical reflection raised by a number of researchers, which cautioned against such optimism, *"one of the subjects said that even if they knew their usage it wouldn't stop them from being wasteful"* (P101).

Such complex human problems can perhaps be best addressed through human solutions. Participants have emphasized the highly social nature of the student lifestyle, and have expressed the importance to them of following the social norms and fitting in. Working with student groups to help establish a norm where this social pressure is exerted towards saving energy may be particularly effective, especially if this is in place from day 1 of students reaching their shared accommodation ([17] had similar suggestions). Interventions that integrate with real world campus activities to support and promote social interaction around themes of energy reduction may be effective (for example holding "no lights" parties), but must be careful to avoid being associated with the "lame" tag with which students typically refer to environmental concerns.

Crucially, our findings suggest that there is one relatively simple intervention that would have a significant effect on student's consumption of electricity in shared

accommodation; the introduction of billed metering. Working with student accommodation providers to design technology to facilitate the introduction and administration of energy metering may be the area of most impact in this space. Importantly, students were generally positive about the introduction of billing. Inspiration could be drawn, for example, from China, where [13] reports that pre-paid energy has recently been introduced in some universities.

CONCLUSION

One hundred participants (students on an undergraduate HCI module) recruited approximately 300 further participants to carry out interviews and participatory design tasks, exploring the design of interventions to motivate reductions in energy consumption in shared student accommodation. Participants' and researchers experiences and reflections were analysed inductively to draw out clusters of themes in the data, and are presented here not to justify a theory, but to help designers maintain connection to participants (see [10]) in their design work.

The work goes beyond the qualitative environmental psychology research reported by [9] through its focus specifically on exploring the design of interventions that use modern technology such as smart meters, smart phones and social networking. It also builds upon the work of Toth et al., [20], which sought to understand the attitudes of teenagers towards energy consumption, but did not focus specifically on the context of student accommodation.

The research method employed principles of both participatory design and practitioner-based inquiry. Specifically, end users (i.e., students) were empowered to influence the design of technology that will directly affect them, through defining the very questions asked, carrying out the research and reporting the data themselves. Thus, the narrative generated from research is inherently and entirely composed of the practical lived experience and reflections of end users. Rather than having the assumptions of designers forced upon them, end users directed the course of the research. We feel this is a major advantage of the method employed.

Another advantage of the method lies in the honesty of the data gathered. It seems that the fact that peers rather than professional researchers conducted the research allowed participants to be uncommonly open and honest in their discussions. In addition, we feel that carrying out research in such close collaboration with students [15] is a uniquely productive approach to teaching and learning HCI at undergraduate level, and one capable of generating publications for tutors.

Ultimately, the contribution of the paper is in the very human reflections present in the data gathered by researchers, which will certainly inform our own project. However, we hope that the breadth and scope of experiences and reflections expressed in these data will encourage in other designers of energy interventions inspiration to engage with this challenge in a way that reflects the complex unpredictability and irrationality of the human experience, rather than appealing to theories that are not validated for this particular context. We hope this work will inspire novel and realistic types of energy intervention.

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