

Designing Student Energy Interventions: A Cross-cultural Comparison

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ABSTRACT

To create successful energy interventions that motivate young people to save energy, it is crucial to understand the context of their energy use behaviours. This paper sheds light on similarities and differences in British and German students' use of energy, attitudes, motivations, and appropriate design suggestions concerning technology-led interventions that aim to foster sustainable energy consumption and behavioural change. Results suggest that students' current use of energy, barriers to energy saving, as well as design requirements for such an intervention resemble each other in both countries. However, British and German students differ significantly in their general attitudes towards saving energy, their willingness to save energy and their knowledge about how to save energy. These findings should be taken into account when designing energy interventions in the UK and in Germany, and more generally, highlight the importance of cross-cultural differences when designing such interventions.

Categories and Subject Descriptors

• **Human-centered computing~HCI design and evaluation methods**

Keywords

Energy; Behaviour change; Persuasive technology; Sustainability; Cross-cultural.

1. INTRODUCTION

When designing persuasive technologies with the main intention to change people's behaviours, it is crucial to carefully collect and study requirements that meet the needs of the targeted users. To this end, motivations, behaviours and attitudes - as well as possible barriers to behavioural change need to be examined [1]. As these determinants are likely to be subject to specific social practices, traits and values which may differ between people with different cultural backgrounds [30], it is important to analyse these factors for each target group to be addressed in an intervention [15].

In response to international environmental concerns [36], the

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development of interactive interventions, which aim to motivate sustainable and pro-environmental behaviour changes, have been increasingly studied by the HCI community. Technology-led interventions which stimulate and motivate sustainable behaviour changes (frequently termed persuasive technologies [8]) have been developed for different target groups in a variety of contexts, ranging from eco-feedback technologies [33] to ambient awareness tools [17] in domestic [34] as well as in organizational [9] settings. Moreover, energy interventions were developed particularly for students living in halls of residence [10, 24, 26, 27]. Most of these behavioural solutions, however, were designed for nationally-specific target groups, giving little insight into the transferability of the suggested solutions in an international context.

In order to provide robust insights into cultural-specific requirements for technology-led energy interventions (TLEIs) designed for students living in halls of residence, this paper describes a qualitative study. The study explores similarities and differences in British and German students' energy use practices; focusing on attitudes towards energy saving, motivations and their needs concerning design requirements for an intervention. The study builds on previous research in the area of understanding student energy consumption [10] by providing a cross-cultural international context.

The design of the study for data collection purposes adopted a focus group approach with 15 students participating from the UK, and 15 from Germany. This produced a large corpus of qualitative data on students' incumbent energy practices and attitudes towards saving energy. Data analysis was carried out using the thematic analysis method [3], providing a rich account of the domain of interest. Findings from the analysis produced a detailed understanding of students' current use of energy, motivators and barriers to energy saving, as well as design requirements for potential interventions. These design requirements should be considered by the HCI sustainability community when designing energy interventions for students domiciled in different countries.

The remainder of this paper is structured as follows. Firstly, an overview of existing technological solutions that foster students' energy saving practices and country-specific findings on pro-environmental attitudes is given. Next, the methods applied within the study and its results are presented. Finally, we conclude with a discussion of the results focusing on the design implications.

2. BACKGROUND AND RELATED WORK

In this section we discuss findings from previous studies which addressed the application of energy interventions in halls of residence and cross-national attitudes towards energy concerns.

2.1 Interventions in student accommodation

In the domestic setting, metered energy consumption typically has direct financial consequences to residents. In contrast, in halls of residence, where students' energy costs are typically charged at fixed prices, such economic consequences do not normally exist [10, 27]. Previous research has shown that for most people costs are often the primary motivating factor to save energy [14]. In the absence of financial motivations the design of TLEIs for halls of residence is a challenging task, and requires careful analysis of students' motivations, attitudes and behaviours in order to target changes in current energy usage practices. To date, only a few studies have addressed the special requirements for energy saving interventions in shared student accommodation. In addition to the research conducted by Foster *et al.* [10] who propose design suggestions for energy interventions in halls of residences in the UK, studies have been carried out in the US and China [24, 26, 27].

Petersen *et al.* [27] evaluated energy interventions in the context of a two week long energy saving competition between dormitories in the US. Students received feedback on their energy consumption in terms of kilowatts and units of air-pollution via a web-based interface and were provided with educational materials on the environmental impacts of people's energy consumption. At the end of the competition, the winning dorm was rewarded with an "ice cream party". During the competition substantial reductions in students' electricity use were reported. However, it remains unclear to which degree students' behavioural change resulted from the feedback, information, reward, or the competition itself.

Odom *et al.* [26] builds on the aforementioned work by Peterson *et al.* and evaluated a feedback interface which facilitated an energy saving competition in halls of residence in the US. Participating students preferred interfaces which not only gave feedback on their energy consumption, but also prescriptive feedback in the form of energy saving tips and social incentives by visualizing the energy saving performance of different dormitories.

Liu *et al.* [24] evaluated energy feedback systems for shared student accommodation in China. In contrast to previous work, the context of evaluation was unique and differed from the studies in the US insofar as students had to pay for their energy use. Students paid for their electricity in advance and if their prepayment balance fell below a threshold of 30 kWh they had to top it up with another advance payment. If students failed to recharge their electricity balance, electricity was shut-off and could only be restored in case of an emergency. In this context, Liu *et al.* designed and deployed a feedback application which was available as a web and mobile application. It visualized students' energy consumption, the remaining energy balance, and the energy consumption of their flat in comparison to other flats. Similar to the studies in the US, the application enhanced students' awareness of their electricity consumption. However, the application was not extensively used by the participants, with low engagement levels manifested. Students generally showed little interest in their energy consumption, even in the context of the prepayment- system and the risk of being exposed to power-cuts.

2.2 Cross-cultural attitudes to energy concerns

The research discussed so far strengthens the requirement for thorough analyses of students' motivations outside the context of financial motivators. As stated earlier, work in this space should acknowledge cultural-specific requirements as an important

attribute of study. As the prepayment-system for dormitories in China has shown, the circumstances and energy-monitoring infrastructure in halls of residence may differ greatly in different countries. This is also true for students' attitudes, motivations and behaviours. Various studies in environmental psychology revealed cross-cultural differences in people's environmental concerns and behaviours [e.g. 7, 30] with diverse implications for the design of effective persuasive technologies for different users. Schultz [30] investigated environmental concerns of students and residents in the US and Spanish-speaking countries. Results suggest people in the US were less concerned overall about environmental issues than people in Spanish-speaking countries. These differences were attributed to cultural issues, such as the collectivistic culture of the Spanish-speaking countries that foster more biospheric attitudes.

To our knowledge, no previous studies which directly compare environmental behaviours in the UK and Germany exist. However, environmental attitudes have been compared in broader surveys across different countries. A very recent study was published by Franzen and Vogl [12]. They based their study on data collected from the International Social Survey Programme (ISSP) and provided insight into pro-environmental attitudes and environmental concerns of 33 different countries. It referred to people's perceived endangerment of the environment by humans and their willingness to protect the environment. According to the study, the means of environmental concern in Germany and the UK constantly declined from 1993 to 2000 and to 2010, whereas concerns were greater in Germany than the UK in each year. This implies the design of energy interventions with feedback focussed on environmental impact of energy consumption may be less likely to engage end-users.

3. A CROSS-CULTURAL STUDY

Given the research discussed above which indicates a general cross-cultural decline of concerns on environmental factors, as well as significant differences around the financial and social implications of energy costs, we wished to find out if there were any differences between students from the UK and Germany. This was in the context of their energy use practices, motivations and attitudes towards saving energy, and their needs concerning a TLEI.

In order to gather information about students' current energy use, their attitudes, motivations and perceptions concerning energy saving and energy interventions, focus groups with students in the UK and Germany were conducted. Focus groups can be used to determine people's feelings, perceptions, knowledge, opinions and experiences on a specific topic and to generate ideas by stimulating each other in a group discussion [22, 25]. Focus groups are also an appropriate method to explore cultural issues and values [16] which is why they are often used in cross-cultural research [19, 20].

3.1 Participants

Focus group interviews were conducted with 30 undergraduate students who were enrolled in a HCI study programme: 15 students from the University of Lincoln in the UK (12 males, 3 females; age between 18 and 25 years) and 15 students from the University of Duisburg-Essen in Germany (5 males, 10 females; age between 18 and 30 years). All participants currently lived or had already lived in shared student accommodation and were able to share their experiences concerning energy use practices in halls of residence. It is important to note that participants were not selected by their ethnicity or their country of origin. Selection criteria was that students were currently enrolled in a UK or

German university. Since participants had grown up or lived in the countries under study for several years, it was assumed that they had integrated with their currently domiciled country, sharing to a limited degree similar social and cultural values.

3.2 Procedure

One of the main challenges of conducting cross-cultural research is collecting reliable and authentic data which is not biased by cultural perceptions and language barriers. This is an extremely difficult goal to achieve if the research is undertaken by outsiders who are not familiar with the participants' culture, communication habits and language [23]. Having insiders as interviewers, who share social, linguistic and cultural characteristics with the focus group participants, can facilitate participants' willingness to share their experiences, mutual understanding and a natural and dynamic group discussion without any linguistic barriers [4]. Moreover, in heterogeneous groups, participant's self-disclosure is often constrained due to different hierarchical levels [20] and also more difficult to compare later on [16].

In order to address these problems for a comparable data basis, and to assure an open and authentic discussion environment, the data of British and German students was collected within homogenous focus groups with interviewers belonging to the same peer group as the participants: Focus groups in the UK were conducted by British students and focus groups in Germany were conducted by a German research student belonging to the same peer group as the German students.

In the UK data was collected from students taking an undergraduate HCI course. They were asked to collect data on design requirements for a TLEI by using different data collection methods, including focus groups, interviews and questionnaires. From the 105 students who participated on the course, 24 opted for the focus group method and recruited participants from their own peer group. Each of the focus groups contained interview data, which were documented and transcribed, and selections made for later data analysis in this work. The selection consisted of six focus groups with two to three participants per group, resulting in data from 15 students. As each student conducted the focus groups on his or her own responsibility, each focus group varied in its procedure, length and question design.

In Germany, participants were recruited via promotions in lectures and social networks. In total, three focus group interviews of 90 minutes with four, five and six participants per group were conducted. In order to facilitate the comparability of the British and the German data, focus groups were organized in a structured way on the basis of a moderation guide [16]. In order to ensure consistency and comparability across the two groups, participants were asked the same questions as the participants in the UK. However, as reported above, there was no consistent set of questions in the UK: during the six UK focus group interviews, many different questions were asked by the moderators. The research challenge here was to aggregate very diverse questions into one consistent set of questions. To this end, semantically similar questions were labelled with category names which represented the question's core content. The question design of the German focus groups only contained categories from corresponding questions that occurred in at least three of the British focus groups. For later data analysis all focus group interviews were audio-recorded and transcribed verbatim in the original language.

3.3 Data Analysis

The focus group data was analysed in its original language using thematic analysis, deemed suitable for analysing qualitative data and exploring patterns within the data in under-explored domains [3]. The data was transposed onto a spreadsheet with each speaker's turn mapped to a row. This was the coeval unit of analysis in order to maintain the comments' contextual coherence. The data gathered in the UK was analysed first and themes identified inductively. Next, analysis of the German data was built on the British data themes, with analysis carried out deductively on the basis of the UK themes schema. In total, 836 units of analysis were coded (153 units in the UK, 683 units in Germany) in the first phase by adding descriptive labels to each unit of analysis. Conceptually similar codes were then collated into overarching main themes and subthemes by refining the data analysis and by reviewing the coherence and consistency of the collated codes (e.g. by identifying overlapping themes and by integrating them) in an iterative process [3, 29].

4. RESULTS

The data analysis disclosed three main themes (current state, motivations and design issues) with further subthemes. Table 1 illustrates an overview of the themes and subthemes and shows which themes occurred in which country (marked with a "+") and which ones did not (marked with a "-"). In the next section, a selection of aspects which were classified under the three main themes is discussed.

Table 1. Themes and subthemes in UK and Germany

THEMES	UK	GE
1 Current state	+	+
1.1 <u>Energy use</u>	+	+
1.1.1 <i>Awareness of energy consumption</i>	+	+
1.1.2 <i>Energy saving practices</i>	+	+
1.1.3 <i>Knowledge of energy saving</i>	-	+
1.2 <u>Barriers to energy saving</u>	+	+
1.2.1 <i>Missing financial incentive</i>	+	+
1.2.2 <i>Convenience</i>	+	+
1.2.3 <i>Missing awareness</i>	+	+
1.2.4 <i>Missing impact</i>	-	+
1.3 <u>Attitudes towards energy saving</u>	+	+
1.3.1 <i>Positive attitude</i>	+	+
1.3.2 <i>Indifference</i>	+	+
1.3.3 <i>Negative attitude</i>	+	+
2 Motivations		
2.1 Saving money	+	+
2.2 Rewards	+	+
2.3 Personal restriction	-	+
2.4 Punishment	-	+
2.5 Competition	+	+
2.6 Environment	+	+
2.7 Awareness of energy consumption	+	+
3 Design issues	+	+
3.1 <u>Technology/platform</u>	+	+
3.1.1 <i>Information display</i>	+	+
3.1.2 <i>Smart metering</i>	-	+
3.1.3 <i>Smartphone app</i>	-	+
3.1.4 <i>Social networks</i>	+	+

3.2 <u>Functions</u>	+	+
3.2.1 <i>Reminder</i>	+	+
3.2.2 <i>Energy usage statistics</i>	+	+
3.2.3 <i>Reference values</i>	+	+
3.2.4 <i>Feedback on environmental impact</i>	+	+
3.2.5 <i>Feedback on saving performance</i>	+	+
3.2.6 <i>Energy saving tips</i>	-	+

4.1 Current State

The data contained in this main theme reflects students' current behaviours concerning their use of energy, and their attitudes towards saving energy. It provides insightful information into the barriers and constraints preventing students from saving energy.

4.1.1 Energy Use

The majority of British and German students reported they were not aware of the amount of energy they actually used in terms of both cost and energy kilowatt units. This is mirrored in comments such as: “No, I really don't know, how much I use- no idea” (GE, P4) or “Yeah, I can't say I know what I use really. Probably a lot when I'm in, but it's hard to be aware of it. Nothing is really there to tell us.” (UK, P6).

While in both countries students seemed to be equally unaware of their current energy use, the data suggests that German students have integrated energy saving practices more in their daily lives than UK students. In the UK, only a few students stated they turned off lights when not being used. However, most of them reported they left lights, laptops, and heating turned on. In contrast, the majority of German students reported they unplugged devices when not at home, washed clothes together with others, and used LED lights and unplugged devices.

Moreover, within the German data the sub-theme ‘knowledge on energy saving’ occurred which was not present in the British data. During the focus groups, almost all German participants demonstrated knowledge of energy behaviours that were pro-environmental. They also showed in-depth knowledge on how to save energy, for example by understanding optimum control of heating settings when leaving the house or by ventilating intensively instead of tilting the window for a long time. More than half the students stated they acquired this knowledge in school, but also friends and family were considered as influencing factors.

Nevertheless, in Germany, nearly all students reported they still wasted energy in some areas, such as leaving lights and the heating on, charging devices over-night, taking long showers, or letting friends take showers for free in the hall of residence.

4.1.2 Barriers to Energy Saving

Students mentioned various barriers that were restraining factors in saving energy.

In both countries the all-inclusive rent in halls of residence, and the resulting missing financial incentive, turned out to be a significant barrier to saving energy: “[...] I would look after it, if I hadn't fixed costs...” (GE, P14) and “Nope, I don't pay for it, so I don't see any need to.” (UK, P14).

The data suggests students were not willing to save energy at the expense of their warmth comfort, well-being and convenience, as well as saving time, having fun by playing games with friends or leaving lights on so it's not dark when coming home: “I'm with that, I leave my laptop and heating on most days. Heat and ease. Who wouldn't?” (UK, P6).

Also, students in both countries considered the missing feedback awareness of their energy consumption as a barrier to saving energy. They received no feedback about their consumption and did not experience the direct consequences of their energy saving practices in their everyday life: “...Yes the problem also is that in Germany you are environmentally not that heavily affected...in the north with all its glaciers, which are melting, or all the little atolls around Australia, which are flooded, in these places people wave heavily concerning environmental protection. But this is all so far away, so I think -Well what is the point for me ?” (GE, P13). Students in Germany exhibited an external locus of control [21], and felt their personal energy saving efforts did not have a real impact on the environment and could not bring about change: “...well I have the feeling that everybody thinks that if he changes something that this won't help anyway.” (GE, P12).

4.1.3 Attitudes towards energy saving

Focus groups in Germany largely exhibited positive attitudes towards saving energy; in the UK students expressed more negative feelings or were indifferent about saving energy. This outlook was reflected in comments such as: “I don't think you can make it [energy saving] cool, you can't make the idea cool, but you can make them think they are doing something else” (UK, P9), “In fact, I'd get arsey if they turned the lights off in the hallway.” (UK, P8).

In contrast, the majority of German students were in favour of saving energy and had positive associations with the concept of saving energy: “It is cool if the person has in mind that he or she wants to save energy...all these impressions of saving energy in your mind that you think about the future and your energy consumption, that you save money – well that is actually cool.” (GE, P5). Moreover, some students in Germany were not annoyed by their flatmates if they switched lights off (like it was the case in the UK), but instead got upset if they left them on: “Well it made me really extremely upset [...] many of them [flatmates] left the light on all night long. Because they got in and out and then...forgot it or they just didn't care.” (GE, P15).

However, indifference was evident also in some German students concerning saving energy: “I think that nobody was really interested in it, because I think that most of the students have lived with their parents before who paid for it - I think nobody really cares about it.” (GE, P12).

4.2 Motivations

This main theme describes factors which motivate students to save energy.

4.2.1 Saving Money

In both countries saving money was considered a striking motivator to save energy: “...as in particular for students who have not a lot of money, costs play an important role” (GE, P13). Students stated if they had to pay for energy or if they got money as a reward or financial compensation linked to their saving efforts (e.g. reduction in student loan) this would truly motivate them to save energy: “Actually the costs are the main reason why you want to save energy, especially because it is so expensive.” (GE, P5).

4.2.2 Rewards

Different types of rewards were considered to be motivational in changing students' environmental behaviour. British students preferred individual, physical rewards (e.g. gym membership, kindle, amazon vouchers or alcohol). While German students also preferred some individual rewards (e.g. vouchers, extended

internet limit, credit points, virtual points), they also leaned towards community driven rewards (e.g. extra cleaning services or equipment for the hall of residence or collective meals or parties). Additionally, some German students considered physical rewards not as effective due to varying personal interests: “*Some think ‘Oh yes, a parking voucher, 50 Euros for free drinks’ whilst others think ‘Oh my god’, ‘why?’ ‘I’d rather prefer a book token or something like that’- and this is difficult.*” (GE, P1). During group discussion, participants in Germany came to the agreement that money was the only common denominator that could motivate everybody.

4.2.3 Restriction and Punishment

Besides measures of positive reinforcement through saving costs or rewards, students also discussed measures of coercive motivational techniques in the form of personal restriction and punishment. Both of these measures compel actions by constraining people’s individual choices physically or perceptually [6]. In Germany, some students felt they would only be motivated to save energy if they were somehow forced to do so, e.g. by restricting the limit of energy available per person in combination with measures of punishment, such as the cutting off or curbing of energy if the limit was exceeded (e.g. lights get weaker, cold water or only certain devices can be used), cleaning the floor or paying extra costs. In fact, the majority of students presented the view that punishment mechanisms were “*definitely*” (GE, P5) more effective than rewards. In the German focus groups it was also mentioned that mechanisms that forced students to check their energy limit would help. For example, students expressed the idea that rooms cannot be entered before the energy consumption was checked. In stark contrast in the UK, the theme of punishment did not occur at all and personal restriction was generally dismissed: “*I like the positive/negative reinforcement idea, but if you took privilege away people wouldn’t like that. They’d probably be less likely to use it or listen to anything it was telling them if it had taken something from them.*” (UK, P4).

4.2.4 Competition

In both the UK and Germany some form of competition was regarded as an effective method to engage and motivate students to save energy: “*Competitive behaviour between flatmates would be good. If you got to see who was winning it would possibly have people strive to do even better just to win.*” (UK, P4). However, in both countries students had serious reservations about competing against each other in groups (e.g. per flat or hall of residence): “*I’d feel like this is a more personal thing, you wouldn’t want people ruining what you’d done or saved if their results were together with theirs.*” (UK, P5). These reservations are in accordance with the fact that British as well as German students tended to be unwilling to admonish others. In turn, they also felt it would be demotivating if they were admonished themselves by others.

4.2.5 Environment

While in the UK only one student mentioned the protection of the environment was a motivator to save energy, in Germany half of the students mentioned this issue. Though, it was stated by some participants they would only be motivated to save energy if they were confronted with dramatic environmental consequences (e.g. via the media).

4.2.6 Awareness

Features that foster awareness of energy consumption and give some positive, thought-provoking impulses, were regarded in both countries as motivators for saving energy. In Germany,

suggestions ranged from an awareness day, where students are asked to reduce their energy consumption, to features that give feedback, to one’s personal energy saving progress and the organization of information events, such as road shows or awareness workshops.

4.3 Design Issues

Comments classified under this theme represent students’ needs and ideas around the role technology can play in an intervention, and other engaging attributes an energy intervention should integrate.

4.3.1 Technology

Data from UK participants concerning the technologies that may be used in an energy intervention was scarce. However, the few comments which related to this subtheme, and which were also supported by the German students, suggested that on-site installations, such as analogue or digital information displays (e.g. blackboards or OLED displays) could be an effective and accessible medium to display students’ individual energy consumption. It was stated that the displays should be placed outside or inside of each room in order to have one’s energy use directly visible when entering or within the room. In Germany, students also emphasized an energy intervention should be easily accessible and smart metering technologies should be used that capture per-device consumption automatically, with functionality to remotely control their use.

In contrast, smartphone apps were hardly mentioned (only twice in the German focus groups) and students in both countries neither considered apps on social networks as an appropriate way to engage students in saving energy: “*The apps on Facebook are crap. Just because you’re interested in something doesn’t mean everyone else is.*” (UK, P8). In fact, only a few students in both countries had positive feelings towards social networks such as Facebook, with negative feelings prevalent in the discussions in both groups. Specifically, the sharing of individuals’ energy consumption was critically regarded as being ineffective: “*No, I think it’s a bit pointless as over time people would ignore the posts.*” (UK, P15). In Germany students pointed out they would share information on their energy saving performance, if any, only with close friends or with a selected group of people (e.g. people living in the same hall of residence) and that they would only share the information if sharing was reciprocal. Generally, students did not like to share information at all, primarily because they were annoyed by too many posts and also because of privacy issues: “*Well, at the latest after PRISM I reduce the sharing of private information to a minimum...*” (GE, P10).

4.3.2 Functions

Both students in the UK and Germany agreed that a reminder function, which gave them timely notifications to turn of lights and other devices, as well as real-time energy usage statistics, should be integrated into an energy intervention for students. In this context, the display of daily, weekly and monthly energy usages (per device, flat or individual), including related energy costs, were regarded as very useful: “*Yes I would like if [...] you really saw how much energy you have used in a month and that you get aware of your usage and also of how much it costs*” (GE, P2). Beyond this, students in both countries considered the importance of rankings and reference values, enabling them to see which devices used the most energy and allowed for comparing their own energy consumption with previous use, or with other people’s consumption: “*Knowing which devices use the most energy or which room uses the most energy will be useful. Making*

the evidence relevant for example comparing the usage to how much an average family of four would use." (UK, P9). It was mentioned that feedback on the environmental impact of one's own actions: *"You've left your computer on all day, this has killed four polar bears!"*(UK, P8), could help to raise awareness of personal energy use and to support reductions. However, in Germany it was mentioned that information about environmental consequences should be provided by the media or by teachers in school and not by an energy intervention.

Finally, students desired to have a third type of feedback, specifically on their personal energy performance (e.g. visualized by happy and sad smileys) in order to understand the progress of their own energy saving efforts. This feedback approach commonly uses descriptive and injunctive norms [31]. The provision of energy saving tips in interventions was briefly discussed by German students. However, there were doubts expressed on the effectiveness of tips, as 'missing knowledge' on saving energy was not considered to be the part of the problem: *"Well the bad thing is that you know most of it already, you just ignore it, this is why I think that tips would not help much."*(GE, P13).

5. DISCUSSION

For the interpretation of the results of this study, it is perhaps necessary to be mindful of the data limitations; the data from the UK and Germany differed in size with slightly different questions. However, possible biases from the latter aspect were reduced by the extraction of a consistent set of questions from the British focus group data.

In general, students in both countries were equally unaware of their energy use and made no secret of their apathy about energy saving in their everyday lives. These findings confirm there is a real need for behavioural change through interventions that foster energy saving practices among students living in halls of residence. Nevertheless, German students seemed at least to try to save energy and had exhibited more positive attitudes towards the environment and energy saving than students in the UK. This is in line with findings by Franzen and Vogl who reported on higher degrees of environmental concern in Germany than in the UK [12]. Previous research suggests that pro-environmental attitudes have significant effects on sustainability-focused behaviours and that the former predicts the later [28]. Thus, the increased energy saving efforts, reported by German students, are likely to have emerged from their generally positive attitudes towards the environment and energy saving. Another explanation for the more pro-environmental behaviours could be that, in contrast to the British students, German students possessed procedural knowledge on how to save energy. This assumption is based on findings from former studies where knowledge turned out to be an important moderator of whether attitudes or environmental concern predicted people's behaviours or not [11] and was also a significant determinant whether people actively engaged in environmental issues or not [32]. The main barriers to energy saving in both countries were the absence of financial incentives due to fixed energy costs in halls of residence. The lack of awareness and impact of their energy consumption as well as their overriding desire for comfort and convenience were considered to be more important than saving energy. Apart from the absence of financial incentives, similar barriers had also been reported in domestic energy usage settings [2] and therefore appear to be an issue that isn't unique to shared student accommodation.

Regarding students' motivations, the data revealed extrinsic rather than intrinsic motivations to save energy dominated the

discussions in both groups. The stimulation of students' extrinsic motivations by coupling students' energy usage to costs, rewards, or wins in the context of an energy saving competition between individuals, was regarded as useful in order to overcome the barriers to energy saving in both countries. All of these aspects have been considered and implemented in previous energy studies and were found to be effective to enhance students' energy awareness and to reduce energy use [24, 27]. However, students in the UK as well as in Germany had reservations about competing against each other in groups, and were generally not willing to take on responsibility for the behaviours of their flatmates, nor wanted to be exposed to possible destructive behaviours by them. Generally, competitions, financial incentives and rewards can leverage considerable motivational effects [14, 35]. However, incentives in the form of money or rewards do not change behaviour sustainably and have rather short-lived effects, as once they are removed, the behaviour is likely to tail off or stop abruptly [1].

In addition to measures of positive reinforcement, German students seemed to be more motivated by the protection of the environment than British students. German students also offered up the possibility of personal restriction and punishment as part of an intervention, an issue which was not discussed in the British focus groups at all or was dismissed by the participants. This might indicate students in Germany were more willing to change their behaviour, and to put their eco-positive attitudes into practice. In fact, a combination of positive measures (e.g. rewards) and negative reinforcement with punitive measures, demonstrates a promising approach to increase behavioural change which the HCI sustainability community could take advantage of when designing sustainability interventions [18].

With respect to the design of a TLEI, students in both countries preferred digital on-site installations rather than smartphone or social network apps. Students' suggestions concerning the features such an intervention should support were quite similar in both countries. Desirable features were i) baseline reference values, ii) raised awareness of their energy consumptions' subsequent impact on the environment, iii) statistical usage, iv) reminders, and v) feedback mechanisms including injunctive and descriptive norms, were regarded as motivating in the UK as well as in Germany. Reference values are generally a good way to support social comparison which has previously shown to be an effective motivator. People are more willing to change their behaviour when their own behaviour deviates from relevant others [35]. In other HCI work the provision of feedback is seen as a core attribute to foster energy saving practices [13]. Feedback mechanisms help people to become aware of their energy consumption, and to better monitor and evaluate their energy use practices [5].

German students discussed the provision of energy saving tips and also considered awareness events, such as knowledge workshops, to be useful. The provision of information and educational material can contribute to higher levels of knowledge on environmental issues, which, as reported above, can also stimulate more ecological behaviours [11]. Prescriptive feedback in the form of energy saving tips and the provision of educational material resulted in effective measures to motivate students' energy saving practices in halls of residence in the US [26, 27].

In summary, data from focus groups in the UK and Germany suggest three similar requirements for a successful TLEI, in the context of students' motivations and barriers to energy saving. Firstly, such an intervention should raise students' awareness of

their energy consumption by making their consumption visible and giving them feedback on their energy saving performance and possible impacts on the environment. Secondly, it should also provide features to monitor students' energy saving performance and to steer students' behaviours more proactively. Finally, an energy intervention should enable social comparison as well as competition between students by displaying the energy saving performance of other flatmates.

However, three striking differences between British and German students emerged from the data which should be taken into account in the design space: First, students in Germany exhibited more pro-environmental attitudes and behaviours than students in the UK. Second, in contrast to British students, German students showed environmental knowledge during the focus groups and knew about energy saving strategies. Third, students in Germany mentioned coercive measures and punishment as potential motivational techniques, methods deemed undesirable by students in the UK.

These differences suggest that when developing an intervention for German students, it should be focused on consequence interventions which build on students' previous knowledge and help to turn their pro-environmental attitudes into action through positive (e.g. reward) or negative consequences (e.g. punishment) [1]. In contrast, for the UK, it is advisable to focus on positive consequences as British students generally had negative attitudes towards energy saving. According to the UK focus group results, negative consequences and coercive measures are likely to result in the rejection and disengagement from an intervention. In consideration of the apparent lack of environmental knowledge and the general negative associations with energy saving among British students, it is also recommended to focus on the additional use of so-called antecedent interventions. Antecedent interventions influence determinants (e.g. knowledge) "prior to the performance behaviour" [1, p.275]. They can for example consist of the provision of educational material and guidelines for carrying out pro-environmental behaviours, workshops or campaigns which aim at increasing students' knowledge in energy saving [1, 6].

Nonetheless, these recommended measures and results from the focus groups suggest that a TLEI alone will probably not suffice to engage students' in saving energy. A lack of environmental knowledge can hardly be compensated for by such an intervention and would require further involvement of external stakeholders, such as policy makers, who initiate antecedent interventions (e.g. education in school or campaigns). A step in this direction for example is the "Student Switch Off" campaign (<http://www.studentswitchoff.org/about-us>) which launched in the UK to promote more environmentally responsible behaviours among students by providing basic energy saving information.

Aspects such as financial incentives, which were regarded as highly motivational to save energy by the students, are generally outside the scope of a TLEI. Indeed, it may provide tools to support the management of costs, but to leverage its effects, a change in the halls' of residence policies (e.g. billing policy) and infrastructures (e.g. smart metering technologies) is required. One pioneer in this field is China. In the framework of a nation-wide "green" campuses initiative, on many campuses smart meters have been installed and, as reported earlier, some universities have also introduced pre-paid electricity systems [24].

6. CONCLUSION

The purpose of this study was to examine similarities and differences in the design requirements for TLEIs between students living in halls of residence in the UK and in Germany. To this end, focus groups with students in both countries were conducted which shed light on students' current use of energy, their attitudes towards energy saving, their motivations, and their suggestions of how such an intervention could be designed.

Students in both countries resembled one another in their use of energy in halls of residence. The lack of awareness of their energy consumption was equally high, resulting from an absence of financial incentives and an unwillingness to save energy at the expense of their own comfort. Thus, the need for interventions that foster student energy saving practices holds true for both countries. The main differences identified, derived from the data analysis, referred to students' attitudes towards energy saving, their environmental knowledge, and their willingness to save energy. German students not only had more positive attitudes towards energy saving, but also showed more energy saving efforts in their daily lives and were willing to accept measures of negative reinforcement and punishment in order to improve their energy saving performance. These findings should be taken into account when designing engaging energy interventions in the UK and in Germany.

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