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UNDERSTANDING COOKING BEHAVIOURS TO DESIGN ENERGY SAVING INTERVENTIONS

Luis C. R. Oliveira[1], Val A. Mitchell[2], Kevin S. Badni[3]

[1, 2, 3] *Loughborough Design School, Loughborough University, Loughborough, UK*

Abstract: People's behaviours play an important role in energy consumption, especially whilst dealing with high consumption, highly interactive appliances such as cookers. In a user observation study conducted among university students, participants were asked to perform a simple cooking task. Their behaviours were analysed and compared with a set of recommended practices. The electricity usage and time to complete the activity were also measured. The results show that participants performed in several different ways, presenting diverse energy usage. The determinants of these behaviours were also collected, and will help to inform the design of interventions to motivate people to change their behaviours whilst cooking.

Keywords: *Cooking observation user behaviour energy saving*

1 Introduction

One of the main sources of CO2 is energy production, and the carbon released into the atmosphere is contributing to make the planet warmer due to the greenhouse effect. The UK government has made commitments to reduce carbon emissions (for example DECC, 2009b), and considerable effort will be required to achieve them. The housing sector accounts for more than one third of the total energy use (DECC, 2009a). If people manage to reduce the expenditure in their homes, it can contribute significantly to the country's objectives.

University students living in a self-catered university hall of residence are the target study population for this research. One motive for choosing this group was receptivity and timing. For most of them, this will be the first time they are away from home and, consequently, they are in the process of learning how to prepare their own meals. This might be an important time to introduce and present best practices, as habits are not yet well formed (Verplanken & Wood, 2006). Learning how to cook in an energy saving way whilst living in university accommodations means they could carry on performing these techniques when living elsewhere.

The cooking context provides a number of opportunities to save energy. For example, according to Wood and Newborough (2007):

[1] l.oliveira@lboro.ac.uk (corresponding author)
[2] v.a.mitchell@lboro.ac.uk
[3] k.s.badni@lboro.ac.uk

- The user is in close proximity to the appliance during use;
- There is a high degree of interaction between the user and the appliance during use;
- There are several energy saving behaviours that the user can apply when interacting with the appliance;

Cooking hobs are generally high energy consumers. Hobs are appliances of low automation that require a relatively large number of controls and settings which can provide several opportunities per operation for the user to engage in energy-saving behaviours. "[W]hile cooking on a hob, the user may need to be in the proximity of the appliance and be available to monitor the end-uses (i.e. cooking food) as well as adjust the appliance controls"(Wood & Newborough, 2007). Their research list six energy saving behaviours that people can perform at home, and each of these can be applied to the use of electric hobs:

"**On/off behaviour**, where the user's action is to manually turn the appliance off to save Energy (e.g. by turning the lights off when not in the room). This also includes [...] switching off at the correct time". The user can control when to switch the hob off, allowing energy saving by interrupting electricity consumption at anytime.

"**Energy frugality**, where the user avoids selecting an excessive power input and acts to reduce the rate of energy consumption (e.g. simmering rather than boiling [...])". By 'turning the hob down' it is possible to reduce consumption while keeping the temperature high enough to prepare the food.

"**Time frugality**, where the user switches the appliance off before the end of the actual period of use". It is possible to turn off the hob a few minutes before the meal is done without compromising the quality of the food. The pan will stay warm because heat continues to transfer from the hob plate to the pan base even though the hob is off. "Any action that reduces energy consumption by more careful time planning is referred to as time frugality".

"**Fitting behaviour** where the user matches the heat source to the volume of liquid/solid that it is designed to heat (or vice versa). For example, a small hotplate is used to heat a small pan instead of a large one". By understanding the right pan to use and the amount of water required to cook, the user can reduce the amount of energy necessary to prepare the food.

"**Inter-appliance behaviour** is when the user chooses to use an appliance which consumes less energy to achieve the end-use than the appliance that they would normally have chosen" For example, the user can chose to use the microwave to prepare certain foods instead of the hob.

"**Alternative behaviour** is when a person chooses to use a non-energy-consuming device or method rather than an appliance". For example, the user can remove food from the freezer in the morning to defrost at room temperature instead of heating it. Or they can also eat raw vegetables instead of cooking them.

Even though the interaction with hobs is a single and isolated activity that users perform generally for a few minutes, there are numerous activities that alter how much energy is spent. One study proved that energy management can reduce the consumption drastically for cooking rice (Das et al., 2006). They performed several experiments to measure and compare the differences between normal and controlled cooking. Controlled cooking experiments were conducted to achieve energy saving by managing the energy input to closely match the actual energy required for cooking. They provided the exact amount of energy needed by turning the heat off as soon the water started to boil. This can be explained by the physical principle that water boils at 100 degrees Celsius, and any energy added will just make the water evaporate faster but will not increase the water temperature. Therefore, to save energy, the ideal cooking temperature is just under 100 degrees Celsius. This study showed that it was possible to reduce the electrical energy consumption by approximately 56% compared to normal cooking. Other research showed that simply using lids on saucepans can make the energy consumption three to five times smaller (Brundrett & Poultney, 1979; cited in Wade, Hinnells, & Milne, 1995). These recommendations found in the literature, together with specific on-site energy measurements helped to produce a set of energy saving techniques to be used during the control phase of the experiment.

There are several studies in the literature reporting attempts to modify peoples' behaviours regarding energy use. Some of them, targeting university students, achieved a relative success by offering feedback, information and financial incentives, but did not try to understand student's behaviours or motivations. (Bekker et al., 2010; Hayes & Cone, 1977; Petersen, Shunturov, Janda, Platt, & Weinberger, 2007). Two extensive literature reviews on energy-related intervention studies indicate that it is possible to increase the effectiveness of an intervention by targeting the determinants of energy use (Abrahamse, Steg, Vlek, & Rothengatter, 2005; Uitdenbogerd, Egmond, Jonkers, & Kok, 2007). It is necessary to identify behaviours that significantly contribute to environmental problems, and also examine factors that make these sustainable behaviour patterns (un)attractive, such as motivations, opportunities, and perceived abilities.

One important aspect of this research is that it is trying to reduce energy use for existing appliances solely through behaviour change. It is understood that there are more efficient cookers and kettles available, but having these appliances does not mean that people will use less energy. Even when living in low energy houses, inhabitants can behave in a non-efficient way (Crosbie & Baker, 2010). In addition, people often have older, less efficient appliances. The challenge is to make people reduce the expenditure whilst using the hardware actually present in their homes.

2 Methods

This study was designed to understand cooking behaviours and gain insight into the determinants of these behaviours. Standard user observation methods as described by Sharp, Rogers and Preece (2007) guided the design of this trial. The sample for this study comprised 20 subjects, 10 male and 10 female, between 18-22 years old, all British undergrad students. They were invited to take part via their academic email, a Facebook group and a poster fixed in their hall of residence. They were asked to cook packet instant noodles as they would normally, without the mention of energy use measurements.

A regular kitchen in a self-catered hall of residence was used for this experiment, and the cooker was equipped with a domestic energy monitor. The same type of cooker (Beko electric cooker with 4 solid hotplate hobs) is fitted in most of the kitchens in this specific hall, so the participants were familiar with the equipment. The energy monitor screen was kept out of sight during the experiment, as not to influence participants' behaviour. A regular kettle was also provided and, since it has a constant consumption, this figure was recorded beforehand using a socket monitor. Its electricity usage during the trials was assessed according to the duration of use. Three different sized pans and lids were made available to participants, as well as a measurement jug. Each session was video recorded to provide detailed information on each action. This approach was chosen due to the complexity of behaviours, the great number of details to be recorded, the automation that some well practiced behaviours present, and the subtle details that could end up unnoticed without video recording. A semi-structured interview followed this observation study to understand why the participants acted as they did. The information was later analysed using NVivo software.

Figure 1 - Kitchen and setup used during the experiment

In order to determine the more energy efficient method for cooking noodles, one controlled experiment was executed. The followed recommendations include: read and follow the packet instructions, keep track of time, measure the amount of water, use the smallest pan, use the lid, choose the smallest hob, reduce heat when it starts to boil, turn off the heat 2 or 3 minutes before the end of the cooking time, and do not boil water in the kettle. It is possible to add extra energy saving tips to this list, but these were selected because they provided a safe option for preparation using regular equipment and utensils, and without too much effort from the user.

3 Results

This study showed surprisingly diverse results regarding user behaviours, time to complete the task and electricity usage (μ 191.4 Watts hour, σ 47.5). These results were compared with best practices showing that the users spent 3 times more energy on average than when following a few simple recommendations. The control study found that it is possible to cook the same packet noodles using only 63 Watts hour by following the energy saving recommendations. Qualitative analysis from the interviews enabled non-energy saving behaviours and a correspondent list of determinants to be developed.

3.1 Behaviours and determinants

The main energy-related issues observed during the observation study were as follows:

3.1.1 Packet instructions

Out of the 20 participants, 5 of them did not read the packet instructions at all. Ignoring the instructions regarding the amount of water and cooking time influenced substantially the overall energy expenditure. During the semi-structured interview, they explained this behaviour as being due to the characteristics of the meal or experience. For example, participant 2 mentioned that *"it's just because you can't really go too wrong with noodles"*, or *"it seems quite straight forward"* (participant 4) or "*it's because I've done it before"* (participant 13). Interestingly, these participants spent more electricity than the average.

Figure 2 – Instant noodles cooking instructions

3.1.2 Kettle

Although it is a common practice, this experiment showed that boiling the kettle increases the amount of energy used to cook noodles. This happens mainly because cooking noodles requires just 200 ml of water, and the kettle found in the students' kitchen has a minimum mark of 500 ml, resulting in boiling more water than needed. In addition, heating the hob and the pan also takes energy and time. 16 participants used the kettle to get boiling water and then poured it in a pan. When asked why they used the kettle, participants explained that they wanted to do it quicker, due to habit and influence of family members. As participant 18 illustrates: *"It's just habit. My parents have always done that, that's why I do, I guess"*.

3.1.3 Amount of water

Just 5 of the participants measured the amount of water used. It affected directly the energy consumption because more energy is necessary to heat more water. It also had an indirect influence as some of the participants kept the noodles boiling for longer, did not use the lid and used high temperature marks in order to make the water evaporate. Their explanations were habit, convenience, the lack of a measurement jug and other issues involving the student's life, as participant 8 explains: *"we don't have one [measurement jug] in our flat, but your own is different, but in our flat, even if we did, it's all filled with alcohol, it's just left dirty from cooking".*

3.1.4 Pan size

Even though bigger pans take more time to heat, 4 participants used the medium sized pan for cooking one single serving due to wrong size judgement or habit. Two participants mentioned that they frequently cook bigger meals so they are used to cooking with bigger pans.

3.1.5 Hob size

8 students used the small hob as recommended for a small pan. Participants who used a bigger hob explained it as habit, convenience, or because they wanted to cook quickly, and they understand that bigger hobs provide more heat. Others justified this option because they have chosen a bigger pan in the first place.

3.1.6 Lid

Just 4 of the participants used the lid on the pan, demonstrating that they understand that it helps keep the heat in and makes the process quicker. The others explained that it is a habit, and using the lid to cook noodles depends on various factors: they wanted to stir it, it is a quick preparation, they believe that there is no need for lids when the water is already boiling, they wanted to let the water evaporate, the instructions do not mention it, their friends do not use it or they do not have lids for their pans. 3 students mentioned that they had problems with the water boiling over, as participant 18 explains: *“normally when I use a lid I just end up with the water boiling over, so I tend to just not use it anymore. Even though I know it keeps the heat in more, but I just normally don't use it, so, you don't get the water like boiling over the top and spilling out”.*

3.1.7 Pre-heat the hob

Metal plate hobs take longer to heat up when compared to other cookers. It induced users to pre-heat it, a behaviour shown by most of the students: *“I’ve done that because in our flat our hob takes a long time to warm up, so I always, like, turn it on first. And then, it’s just quicker to cook”* (participant 13). Commonly, students pre-heat the hob whilst boiling the kettle: *“[I pre-heat the hob] because the kettle takes longer to boil. And whilst it’s boiling, I pre-heat the hob because it takes ages to heat up. So it would just heat up faster, [...] otherwise the hot water would start cooling down because the hob isn't as hot yet”* (participant 20).

3.1.8 Heat level

Most of the participants reduced the heat level at some point during the cooking process. They understand that it can help avoid overcooking and also boiling over. But some participants explained why they keep the heat up towards the end of the process: *“I normally just put it on high heat, just to heat the food fast. I know if you do it slowly it cooks better, but sometimes you just want a quick meal, so you just put in a high one”* (participant 8).

3.1.9 Remaining heat

One important characteristic of solid plate electric cookers is that their hobs keep hot for a few minutes after the heat is switched off. Only 3 of the students demonstrated awareness of it, for example participant 16: *“Well, once i knew that it* *was nearly cooked I just decided to turn off the heat and let the residual heat from the ring just cook the rest of the food, usually just to try to save a little bit of energy at the same time".*

3.1.10 Timing

7 of the participants kept track of the time using their mobile phones. The others just checked it visually or tasted the noodles to see if they were ready. This lack of control resulted in diverse time usage, as can be seen in Figure 3. Their explanations for not timing the process were personal preferences, like participant 11 points out: *"I tend to go by my taste. And if I think it's ready, because it's me who's got to eat it, so, if I think it's ready I'm happy to eat it, then I will".* Other participants mentioned that they are experienced: *"Well, because I cook noodles quite often, I know what they look like when I like them ready. So I didn't keep the time because I thought I know by sight now, when I think it's done"* (Participant 5). Another reason for not timing is that the cooking time might vary according to the cooker being used: *"I do realize sometimes the instructions are wrong, depending on the cooker and stuff like that, that sort of thing. So you may end up cooking it a bit longer, so I've had that before, that at home I cooked, like, just exactly what it is said on the packet, so it hadn't been cooked properly"* (participant 15).

3.2 Energy and time usage

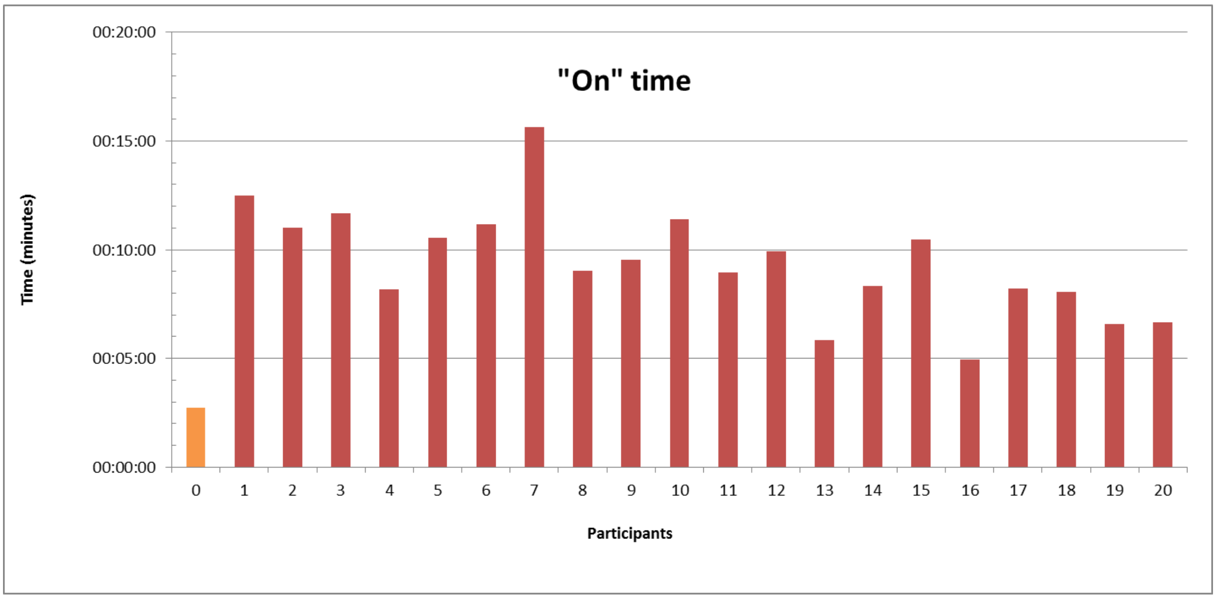

Figure 3 - Time effectively using electricity, per participant.

The analysis of the video data showed that participants used electricity from 5 to over 15 minutes to cook the noodles, as can be seen in Figure 3. During the controlled experiment, the researcher implemented the energy saving techniques (shown in the chart as participant 0). Less than 3 minutes was needed to bring the noodles to boil and it was sufficient to provide heat to cook it for another 2 ½ minutes, as recommended on the food packet.

Figure 4 shows the amount of electricity used by each participant, compared with the researcher (participant 0) who implemented the set of recommended energy saving techniques. The extreme variation on energy and time usage can be explained by the amount of time that the participants left the hob on, the mark used and also the size and position of the hob chosen. The two front hobs are ‘fast heating’ rings, and for that reason they consume more electricity when on mark 6 (Beko, 2011). The darker bars represent the energy used by 16 participants when boiling the kettle. Variations on these numbers are due to the volume of water used.

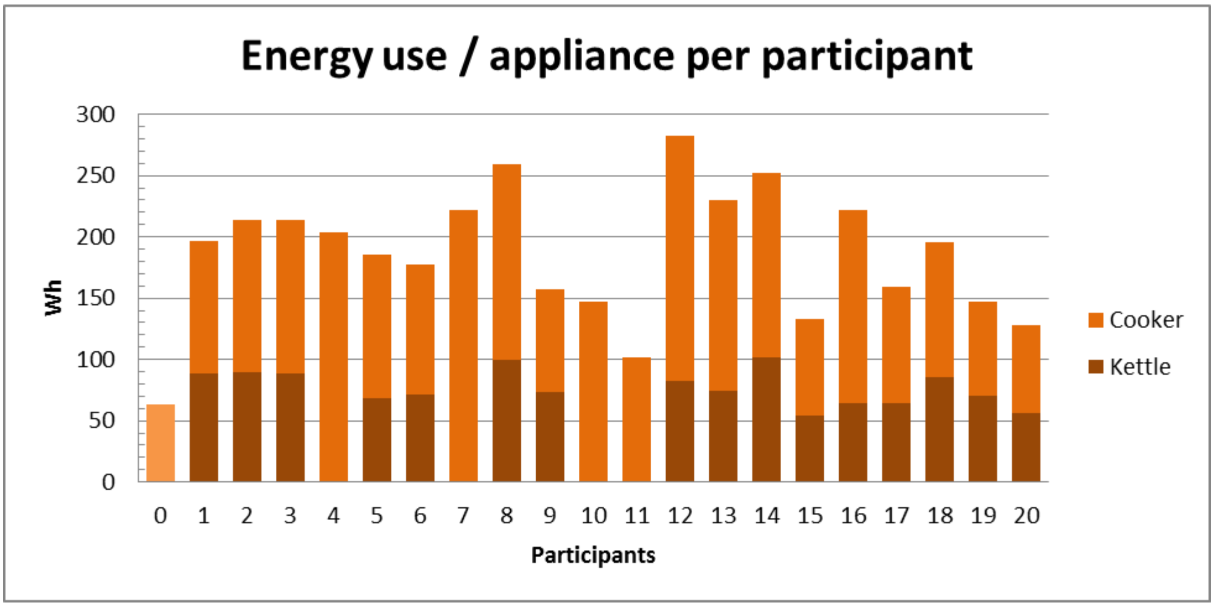

Figure 4 – Watts hour used per participant combining cooker and kettle (when used)

4 Conclusion

During this user observation study it was noted that participants behaved in diverse ways, even if cooking the same simple meal using the same appliances and utensils. As a result, the electricity usage and the time to complete the task varied remarkably. It was also noted that participants have their own motivations, preferences and reasons for behaving as they did, often due to a lack of knowledge of how the cooker works, because they wanted to cook quickly, and due to convenience, habit or external factors like the lack of adequate utensils. As these participants live in an all inclusive hall, they are not motivated to save energy since they do not pay bills directly. Consequently, there is no financial incentive to use electricity reasonably. Environmental concerns were seldom mentioned, meaning that any discourse trying to motivate them has to go beyond the environmental impact of energy use. In order to be successful, an intervention aiming at changing their behaviours must consider the determinants of their behaviours (Abrahamse et al., 2005). Furthermore, the overall outcomes of the intervention must benefit them in some other way as they have their own interests (Crosbie & Baker, 2010). The designed intervention must offer guidance on the energy saving methods, but must also provide other advantages to the participants, for example it must help them cook quickly and improve the quality of the food. To increase the chances of success, this intervention cannot compromise the cooking results, increase the time to prepare or be an inconvenience for them in the attempt to save energy. Further work is being performed to develop this intervention, with which participants will hopefully have a fun and engaging user experience. The effectiveness of such intervention in reducing energy use will be later assessed.

5 Acknowledgements

The researchers would like to acknowledge the Loughborough Design School, Loughborough University, United Kingdom, for funding this PhD program.

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