Working with Teenagers to Design Technology that Supports Learning about Energy in Informal Contexts

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Abstract: Energy sustainability is prevalent in political and popular rhetoric and yet energy consumption is rising. Teenagers are an important category of future energy consumers, but little is known about their conceptions. We report on research to design learning technologies that support teenagers' learning about personal consumption of energy. In this paper we describe our analysis and methodology, which are shaped by the Ecology of Resources design framework (Luckin, 2010). Findings suggest teenagers are aware of energy issues at an abstract level, but do not apply this information in the context of their behaviour. We identify indirect energy use and the relative energy intensity of different behaviours as important areas for learning. For example, behaviours of particular relevance to teenagers are use of electronic devices, and choice of food and personal care products. These findings have implications for the design of technology to support learning about energy in informal contexts.

Introduction

Climate change and resource scarcity have brought energy sustainability to the forefront of environmental concerns. However, contrary to the need for adoption of energy sustainable lifestyles, energy consumption is rising and few people take measures to save energy (for UK trends see Whitmarsh, 2009). Indeed, few studies have found that consumers adopt energy saving behaviours *over the long-term* even when specifically targeted by intervention studies (see review by Abrahamse, Steg, Vlek & Rothengatter, 2005). Evidence also suggests people are unwilling to adopt behaviour changes that have a high impact on energy demand (Whitmarsh, 2009; Gatersleben, Steg & Vlek, 2002).

An important factor in shaping future patterns of energy consumption is the attitudes and willingness to address the problem by younger generations. Little is known about teenagers' conceptions of the issues around energy use and their attitudes towards the adoption of energy sustainable lifestyles (Wray-Lake, Flanagan & Osgood, 2010). However, the pattern of increase in energy consumption coupled with evidence implicating teenagers in increased energy household bills (Thøgersen & Grønhøj, 2010; BBC, 2006) suggests few are consciously acting to save energy. The reasons for this are likely to be complex. Behaviour is influenced by many factors, including knowledge, attitudes and concerns as well as contextual factors, such as habit and availability of alternatives (Stern, 2000; Whitmarsh, 2009; Gatersleben et al., 2002). Therefore, the lack of conservation behaviour may not necessarily reflect a lack of awareness or understanding. That said, there is evidence that teenagers' concern about the environment and adoption of conservation behaviours has been declining (Wray-Lake et al., 2010). Also, studies with adults suggest there is both misunderstanding of the energy intensity of different behaviours as well as a more general lack of awareness regarding the connection between environmental issues that arise from energy use and individual consumer choices (Lorenzoni, Nicholson-Cole & Whitmarsh, 2007; Crompton & Thøgersen, 2009; Steg, 2008; Chauhan, Rama das, Haigh & Rita, 2010). This disconnect between individual actions and larger scale problems, and the lack of awareness of *how* one might act to make a difference suggests the need to link learning about energy and energy related environmental problems with everyday concerns, motivations, and choices. For teenagers to change their energy behaviours they must be motivated to engage with energy related problems in the context of their everyday lives and also helped to develop the skills to explore the impact of their behaviour. In this paper, we report on ongoing work to design learning technologies that support learning about energy in the informal contexts in which teenagers might make energy conscious choices. Our work contributes to research within the learning sciences community to design technologies that support scientific learning in informal contexts (Zimmerman, et al. 2010; Clegg, Gardner & Kolodner, 2011). Specifically, we discuss the application of a methodology for designing learning technology that identifies the learner's context and draws connections between their circumstances, motivations, attitudes and knowledge.

Consumer Awareness of Energy Consumption

Energy consumption has been increasing over recent years (Abrahamse et al., 2005). It is estimated that households are responsible for between 15 and 20% of national energy consumption in western countries (Steg, 2008; Abrahamse et al., 2005). Hillman (2004, reported in Lorenzoni et al., 2007) reports individuals' contribution to energy demand in the UK, including household and transport, at 51% of national energy use. Of

this, estimates show around half is due to direct energy consumption, such as house heating, water heating, cooking and lighting, and the other half to indirect energy demand through consumption of products and services (Reinger, Vringer & Blok, 2003). Supporting individuals to adopt energy saving behaviour, therefore, can potentially have a significant impact on national energy demand.

The majority of research on attitudes towards energy and adoption of energy saving behaviour has focused on adult consumers. In terms of awareness, these studies suggest people are concerned about the environment, but do not see climate change as an immediate threat and if they do save energy it is mainly for financial reasons (Lorenzoni et al., 2007). There is widespread lack of awareness of the behaviours that impact on energy demand. For example, many people report they adopt recycling to tackle climate change, when in fact recycling has a low impact (Whitmarsh, 2009). Moreover, there is evidence that people are not aware of the energy intensity of different behaviours, such as heating water (Steg, 2008), and tend to attribute greater impact to those behaviours they have adopted over those they have not (Crompton & Thøgersen, 2009). More generally, there appears to be a disconnect in understanding the source of environmental problems in individuals' behaviour (Lorenzoni et al., 2007). Of greater concern are the findings that people are more willing to adopt changes in their behaviour that do not require much effort and change in lifestyle, such as recycling, but which have small impacts, and much less willing to adopt behaviours that have high impacts but are inconvenient, such as choosing alternatives to car travel (Lorenzoni et al., 2007; Crompton & Thøgersen, 2009; Lindenberg & Steg, 2007). It is also reported that intervention programs that target behaviour changes have been less successful in changing high impact behaviours (Chauhan et al., 2010).

We know little about teenagers' attitudes and behaviours, we can however observe that current trends in energy consumption would suggest that few teenagers are engaging in high impact energy saving behaviour. It is also likely that their understanding of the energy intensity of different behaviours mirrors that of the adult participants as reported in the aforementioned research. Some studies that have involved teenagers have presented a negative picture of their contribution to energy consumption (Thøgersen & Grønhøj, 2010; BBC, 2006), and reported evidence of decline in environmental concerns (Wray-Lake et al., 2010).

Teenagers' Role in Energy Saving

Teenagers are not the principal decision-makers within the household but they are well placed to have an impact, both by changing their individual behaviour and by acting to influence others within the family, their social network and the public sphere (Larsson, Andersson & Osbeck, 2010). Public campaigning has the potential for greater change, because the adoption of many energy saving behaviours is hindered by contextual factors that must be addressed by organizations and government (Stern, 2000). For example, the availability of alternatives to car travel will facilitate or inhibit their uptake.

It is important that teenagers' behaviour change related to energy use is coupled with knowledge and awareness and not achieved solely through other motivations. Knowledge is an essential addition to other factors, such as the financial and contextual influences that have been found to be strong determinants of energy saving behaviour (Stern, 2000; Abrahamse & Steg, 2011). Change that is based on knowledge, awareness and concern is likely to be more robust than changes in circumstances alone (Lindernber & Steg, 2007). By contrast, if change is based on reward, the moment the reward is removed or is no longer of significance, energy use will return to higher levels. Knowledge and awareness are also important because they are essential for influencing others. In order for teenagers to become effective agents for change, they must be informed about why energy is a relevant issue and about how people can act to mitigate the environmental problems that arise from current energy consumption. However, for the learning experience to be effective, information must be tailored to personal circumstances and made relevant to individuals' behaviour and choices. The adaptability, flexibility, and portability of learning technologies makes them well placed to create learning experiences that are personalised and that embed information about energy and energy saving into teenagers' contexts.

Framework for Learner Centred Design

Technology has been used to good effect to support science learning, particularly in collaborative settings and when the learners' broader circumstances are taken into account (see for example, Pea, 2002; Puntambekar and Kolodner, 2005). A methodology that identifies the multiple influences upon teenage decisions and behaviours, and that draws connections between their circumstances, motivations, attitudes and knowledge is required for the design and use of technology to support learning about energy. This methodology needs to be participatory and to engage the teenagers in the design process in order to ensure that a clear and accurate understanding of the complex influences within their personal contexts is integrated within any resultant design. The Ecology of Resources design framework (EoR, Luckin, 2010) offers a process for working with participants that models and takes account of their context. The framework is inspired by a sociocultural philosophy to understanding and supporting learning (Vygotsky, 1978, 1986) and the notion of scaffolding, which defines the process of providing support that is closely contingent on the learner's current understanding and skills (Wood, 1976, Luckin at al, 2011; Pea, 2004). The EoR provides a method for designing learning technology and/or learning

technology use that considers the important relationship between the learner in their context and the learning that arises out of their interactions with their context. The EoR conceptualizes a person's context in terms of their interactions with the multiple resources of their world, for example, with the people, places, books, knowledge concepts and technologies they encounter; and in terms of their personal resources, such as their motivation and existing understanding. In order to support learning the design process seeks to effectively link the world resources that are most appropriate for a specific learning goal and to scaffold interactions between these resources and the learner, taking into account the learner's personal resources.

The EoR provides a method through which we first identify the world resources available to the learner and the processes and relationships that shape the learner's access to these. We also build an understanding of the learner and what they bring to the learning experience: their personal resources. The EoR also introduces the notion of *filters* to describe the artefacts that constrain a learner's access to resources, such as rules, regulations or physical boundaries. Having mapped out the learner's context we begin an iterative participatory process of design with the aim of developing technology that facilitates access to appropriate resources at appropriate times during the learning process. The EoR has been used with learners and teachers across a range of subjects, including science and language learning to design technology rich learning activities and technology applications, such as smart phone applications (Underwood et al, 2011).

The EoR design process offers a 3 Phase structure through which educators and technologists can work together to develop technologies and technology-rich learning activities that take a learner's wider context into account. In this paper our focus is on Phase 1 (see Luckin, 2010 for framework detail):: Create an Ecology of Resources Model to identify and organize potential resources for learning. Six iterative steps support the modeling process in which some steps will require completion multiple times. Step 2 is of particular importance and can require several iterations through other steps:

Step 1 – Brainstorming Potential World Resources
Step 2 – Specifying the Focus of Attention
Step 3 – Categorizing World Resource Elements into: Knowledge and Skills, People and Tools, Environment.
Step 4 – Identify potential Resource Filters
Step 5 – Identify the Learner's Personal Resources
Step 6 – Identify potential More Able Partners (MAPs).

Phase 2: Identify the relationships within and between the resources produced in Phase 1. Identify the extent to which these relationships meet a learner's needs and how they might be optimized.

Phase 3: Develop the Scaffolds and Adjustments to support learning and enable the negotiation of a Zone of Proximal Adjustment (ZPA) for a learner. Phase 3 of the framework is about identifying the possible ways in which the relationships identified in Phase 2 might best be supported or scaffolded. This support might for example be offered through the manner in which technology is introduced, used or designed.

Research Questions

The study reported here is part of ongoing research to design technologies that will support learning about energy issues and the energy intensity of individual behaviour and choices. The design of these learning technologies will be based on identification of: *appropriate areas of focus for learning*, *an understanding of how to motivate teenagers to engage in learning about energy*, and *an understanding of how the technology can fit in with the learners' context* in order to make the link between the learning material and the (everyday) context in which it applies. To this end we need to identify and understand the resources available to teenagers:

1. Teenagers' personal resources: conceptions of energy issues (what are the priority areas for learning?)
    a. How do they understand energy use and saving in their everyday life?
    b. How aware are they of their energy use?
    c. How much knowledge do they have about the energy intensity of their behaviour and choices?
2. Teenagers' personal resources: concerns and motivations (how do we motivate teenagers to engage?)
    a. Are they concerned about energy issues?
    b. What are their attitudes towards energy saving?
    c. What motivates them to save energy?
3. World resources available to teenagers (how will the technology fit into teenagers' ecologies of resources?)
    a. What energy uses are most relevant to them?
    b. What are the circumstances in which they use energy?
    c. What are their sources of information about energy and energy saving?

Study Design

Participants

Our participants were a group of 14 teenagers (aged 14-17; 5 female and 9 male) who were taking an IT course at an international school in the UK. Our sample is not representative of the teenage population. However, their

conceptions of energy use and motivations are very relevant. They come from families with higher incomes who are therefore likely to be greater consumers of energy (Abrahamse & Steg, 2011), both now and in the future. In subsequent studies we plan to compare our current findings with those from teenagers from state schools.

Method

The course teacher integrated our research on energy with a course project in which students documented and presented how they use energy and what they could do to save energy. The project was completed shortly after they participated in our study. This allowed us to work with the students over 3 sessions and also to gather data from a presentation of their formally assessed work. We used a combination of photo diaries and focus groups to explore the research questions.

Photo diaries

In our initial exploration of teenagers' learning contexts we designed an activity that would be open-ended and not explicitly related to energy. We did not want to prescribe the kinds of things they identified as relevant to energy. Therefore, we gave participants the activity of creating a photo diary of a day in their lives. In preparation for this activity, we dedicated a separate session to the discussion of anonymity in taking photos in line with ethical constraints. We gave the opportunity to participants to practice taking photos that captured an activity but did not identify people. We did not provide reminders, for example to take a photo at set time intervals, because we were interested in what activities the participants would choose to document. Instead we asked them to document any change in activity in order to create a diary of a day in their life with the guideline to aim for 24 photos in a day. Although by necessity the consent forms did mention the energy focus of our research only two participants mentioned energy when discussing their photos and in fact the activities they documented in their diary were not limited to what activities they identified as being relevant to energy use in the focus groups. The session in which we discussed the photo diary activity and gave the participants the digital cameras was on a Friday. They were asked to complete the diary starting from Friday afternoon to Saturday in order to capture activities both in school and at the weekend.

Focus groups

The photos from the diaries were revisited in a subsequent session in order to translate them into a narrative. This session took place 2 days after the photo diaries were created. Participants worked in groups of 3-4 and took turns in creating their narrative by laying out the photos as a storyboard. Within the group each teenager was assigned a role of either interviewee (the person whose diary was being discussed), interviewer(s) or note-taker. The interviewer(s) were given the following questions to ask the interviewee in order to help create the storyboard: a) What were you doing when you took the photo? b) What else was going on around you? c) How long were you doing this activity for? and d) Why did this activity end?

Once the narrative was complete we discussed the activities that were captured in the photos through the lens of energy consumption. In these discussions we explored teenagers' awareness of energy-related issues, their attitudes and their behaviour. As before, each teenagers within the group was assigned roles of interviewee, interviewer and note-taker. For this discussion we provided the following questions: a) Is what you were doing related to energy use? If yes, then in what way is it related to energy? Where you conscious of how much energy you were using? Could you use less energy? Would you choose to use less energy? b) Are there times when you intentionally use less energy? If yes, when? c) Are you concerned about energy use?

Formal presentation and small group discussion

After the 3 sessions the students were required to complete a formally assessed project on ways in which they could reduce their energy use. They visited the university department to present their work to our colleagues. After the general post-presentation discussion we divided the participants into groups of 4-5, with one of the researchers leading the discussion in each group. In these small group discussions we used some of their photos from the photo diary activity as prompts to probe into their conceptions further. Specifically we focused on indirect use of energy, which we had identified from our analysis of the photo diaries and focus groups that they appeared to have less awareness of (photos of a bottle of water, filtered water, a zero-sugar soft drink, food (a burger), and clothes). The focus groups, presentation and small group discussions were audio recorded for later analysis.

Findings

We report on the first iteration of Phase 1 of the EoR process of design, which involves identifying the resources that make up the learners' contexts in relation to energy use and forming an understanding of the learner and their personal resources. We have structured our findings based on the research questions. In the subsequent discussion we reflect on how these findings inform the identification of a focus for learning and motivation for teenagers to engage in learning.

We analysed the data by an iterative process of identifying themes. We extracted those conceptions, motivations and context elements that recurred across participants and across data sources (photo diaries, focus group discussions, formal presentation, and small group discussion).

Teenagers' personal resources: conceptions of energy issues

How do teenagers understand energy use and saving in their everyday life?

The discussions of energy mostly concerned *electricity* and the use of *electronic devices*. This focus also came through in the participants' formal presentation, where most focused exclusively on electricity. Only two participants mentioned other uses, that is, amount of hot water used to shower and the energy required to produce plastic water bottles and paper.

This focus on direct energy use and lack of awareness of indirect energy use is interesting principally because when prompted about indirect energy use *explicitly* participants engaged in discussion about it. In the small group discussions (which we engaged in after the formal presentation), we prompted participants with selected photos of food, drink, and clothes, with the aim to elicit their conceptions around indirect energy use (as we had identified this as an area of low awareness from the photo diaries and focus groups). During the discussion participants discussed several issues including production, transportation, refrigeration (in the case of food and drink), packaging, and waste processing of products. When prompted further they also discussed the relative energy intensity of different foods, for example meat versus vegetarian products.

This apparent distinction between the energy they use directly and the energy used indirectly in the products they consume also emerged in their focus on energy use that is *solely due to their behaviour*. In other words, shared use of electricity, for example, in the family's use of the dishwasher, or the use of classroom computers was only considered after prompting. For example, in the discussion of each photo diary we came across several pictures of food. The participants were prompted to consider what uses of energy are associated with, for example, their dinner, which led to a discussion about the use involved in dishwashers, microwave ovens, and refrigeration. Their ideas for saving energy were also limited to *using less* but not *consuming different products* or *engaging in different activities*. For example, switching off devices when not in use, or using their laptop less.

It appears the concept of energy and energy saving is closely tied with *not wasting* more generally, and it is closely linked with not wasting other resources. For example, during the photo diary discussions many participants mentioned water (though not heating water) and compared not wasting electricity with not wasting water. When asked specifically about food in the small group discussions, the focus for many was again on waste. Similarly with clothes, the focus was on not throwing them away and handing them down to others. From the focus groups it emerged they are prompted by their parents to not waste electricity and water, and many are given their siblings' clothes, and so it seems natural these are closely linked ideas.

How aware are teenagers of their energy use?

Almost all participants reported they were generally not aware of their energy use prior to engaging with us. Their teacher also confirmed the difference in their awareness over the course of the study. The only instance they discussed of being aware of energy use and acting to save energy was switching off the lights and music players when they left the room, as prompted to by their parents. We note that while they were able to discuss the different uses of energy, even indirect uses when asked explicitly about it, this information was not translated into awareness of energy use in their everyday life until we prompted them to reflect on it.

How much knowledge do teenagers have about the energy intensity of their behaviour?

The participants discussions of how they could save the most energy indicated little awareness of the energy intensity of different behaviours. They appeared to base their calculations of the amount of energy used by how long a device had been switched on. For example, because a fridge or phone is continuously in use it was assumed to use more energy. Discussions around indirect energy use suggested that, while they were aware of indirect energy requirements, they considered it negligible in comparison with energy used by lights or electronic devices.

Teenagers' personal resources: concerns and motivations

Are teenagers concerned about energy issues?

There was general agreement that energy related problems are important and relatively urgent issues. The problems discussed included climate change, resource scarcity, and animal habitat destruction. However, the participants did not express great concern. Some suggested problems would be resolved through improved technology, while others simply did not appear to have reflected on the issues and did not elaborate on their concern.

What are teenagers' attitudes towards energy saving?

For the majority of participants the responsibility of alleviating the problems around energy use does not lie with them. Some were willing to take responsibility for individual actions and stated that each should lead by example. However, their perception was that this is not something they *should be expected* to take responsibility for. This finding is not surprising but it highlights an interesting issue in perception of responsibility more generally. For these teenagers the question of whether they should act appeared to be about it being unreasonable for us *to expect them* to act. It was not seen as a problem that affects them and, consequently, they might *choose* to do something about.

When we discussed their willingness to change their behaviour in order to save energy, they seemed very willing to act to prevent waste but not to modify their lifestyle. They also doubted that anyone else would be willing to change. Their focus was very much on limiting amount of use rather than finding alternatives. In relation to indirect energy use, as we've discussed they did not consider indirect energy use to have as great an impact, so did not discuss purchasing alternative products or services. When queried about what factors would affect their purchases their focus was overwhelmingly on money, but also on the impact on people. For example, they would not buy clothes that involved child labour.

What motivates teenagers to save energy?

None of the participants reported that they consciously change behaviour to save energy. The only motivation was their parents' telling them to switch off the lights and electronic devices when not in use.

Teenagers' contexts

Our focus in addressing this question was on the kind of activities the participants engage in and the choices they make. We analysed all the data (from the photo diaries, focus sessions, formal presentation, and small group discussions) by firstly identifying all the activities, contexts of use, people and products, secondly selecting the ones that occurred with the greatest frequency, and finally grouping these into the EoR categories: Knowledge and Skills, People and Tools, Environment.

People and Tools: What energy artefacts are most relevant to teenagers?

We identified three groups of energy artefacts that are most relevant to our participants: electronic devices, food, and personal care products. Although there was individual variation within each category, there were some common products across participants, such as laptops, phones, music players, drinks (energy drinks), and water (bottled, filtered, tap water).

Environment: What are the environments in which teenagers use energy?

The main environment that appeared in the photo diaries and formal presentation was the home. School and restaurants also featured in the photo diaries but were exceptions.

Knowledge and Skills: What are teenagers' sources of information about energy and energy saving?

The main source of information the participants mentioned explicitly, and that was brought up in discussions of energy, were their parents. However, this was only in relation to not wasting energy. In terms of facts about energy use and energy intensity of behaviours some mentioned TV programs. For example, one participant mentioned a program about the amount of energy that can be saved through recycling. It is worth noting when information from TV programs was mentioned it was presented with uncertainty as something that they had heard but couldn't quite recall the details of.

Discussion

The study we report in this paper is part of ongoing research to support teenagers in learning about energy issues and the impact of their individual behaviour and choices. We engaged with teenagers using qualitative methods (photo diary, focus groups and formal project work) to identify important areas of focus for learning, to understand how to motivate teenagers to engage in learning about energy, and to explore how the technology can fit in with the learners' context in order to make the link between the learning material and the (everyday) context in which it applies. Our work contributes to research within the ICLS community that is concerned with the design of learning technologies to support science learning in informal contexts (for example, Zimmerman et al., 2010). The design of learning technologies must tap into learners' motivations and identify the multiple influences and resources within the learners' context. The methodology needs to be participatory to ensure that a clear and accurate understanding of the learners' personal contexts is integrated within any resultant design. The EoR methodology that we applied offers a process for working with participants that models and takes account of their context.

We purposely used open ended tasks that did not focus on energy from the beginning. This was important in understanding the participants' informal contexts as filtered by what they considered *relevant* to their lives and also *acceptable* for us to 'see'. The data also confirmed the importance of an open ended method for exploring teenagers' awareness in the context of their everyday life and differentiating awareness and knowledge in this context from the more formal knowledge they have about energy. For example, when we discussed their photo diaries indirect energy use was hardly touched upon. However, when we used some selected photos from the diaries to prompt them explicitly about indirect energy use related to food and water we generated a discussion around energy requirements for production, transportation, storage, and disposal. Had we only conducted a focus group around examples of indirect energy use we might have assumed this information would be readily available at all times. Our focus on the photo diaries also allowed us to centre the discussion around instances of energy use that were personally relevant and, therefore, probably more engaging.

The combination of multiple sources of data was also important to our method. The photo diary and subsequent focus sessions allowed us to probe into the learners' informal contexts and the nature of their conceptions within those contexts. The formal project work around participants' energy use and ways they

could save energy gave us an insight into their formalized notions of energy use, especially as it was conducted after the diaries and focus groups. When we started the study they had not yet explored their energy use so were still at their pre-study awareness levels. When they began the formal project work they had already engaged in discussion around energy use with us. Therefore, it is reasonable to assume that what was distilled in their formal work represented core ideas (for example, the focus on direct energy over indirect, and their perception of the relative energy intensity of different activities).

Motivating teenagers to engage with energy issues will be the biggest challenge. Although they report concerns, it seems the problems around energy use are too abstract for them to make a connection with their lives and the people and things they care about (as appears to be the case with adults, Lorenzoni et al., 2007). It will be critical to foster understanding of the impact of energy issues on people, both those close to them and those further away. Our data suggests that they are concerned about the impact of their choices on people. For example, it is possible the concern they reported about child labour in buying clothes might extend to concern about populations who are more affected by energy related problems.

In terms of the knowledge the teenagers would bring to the learning experience, our findings on teenagers' conceptions of and attitudes to energy use and energy saving largely echo those reported from research with adults (Lorenzoni et al., 2007; Crompton & Thøgersen, 2009; Steg, 2008). Our participants were aware of energy issues at an abstract level, but this did not translate into an awareness of energy use in the context of their individual behaviour. Their conception of the relative energy intensity of different behaviours was not very accurate (for example, the assumption that the fridge uses a lot of energy because it is on all the time), and indirect energy use was largely invisible to them until prompted.

It, therefore, appears that what is of critical importance for this group of teenagers is to raise their awareness of the energy intensity of their behaviour and choices. Especially the lack of awareness with regards to indirect energy use which is important given the fact that indirect energy use accounts for around half household energy use. Another reason to focus on indirect energy is that in our analysis we identified it as one of the most relevant to this group of teenagers, specifically in the consumption of food, water and personal care products. Also their focus on personal energy use suggests we need to make their contribution to shared (within the family) and public energy consumption more salient.

More generally, the issues around energy might be best conveyed in conjunction with other environmental issues. The participants' thinking about energy was not clearly differentiated from other resources, such as water. Moreover, the idea of saving was generally interpreted in terms of not wasting rather than changing behaviour to adopt less energy intensive alternatives. This is coupled with a willingness to cut back on waste but a reluctance to make changes that require sacrifice, such as not flying as frequently (which is consistent with adult research, Lorenzoni et al., 2007; Crompton & Thøgersen, 2009; Lindenberg & Steg, 2007; Chauhan et al., 2010). This again suggests we must raise awareness of the impact of behaviours, for teenagers to be in a position to judge whether cutting down on waste is enough. It also suggests that it might be productive to frame energy reduction in general in terms of wastage.

In terms of the sources of information in teenagers' lives that learning technologies could tap into, parents seemed to have the greatest influence but this was limited to not wasting energy by switching off lights and electronic devices. In this group of teenagers at least, there appears to be scope for them to educate their parents. Other information from media was occasionally mentioned, but the uncertainty with which it was presented suggests that the learning technologies we design need to help teenagers capture this information and then actively try to reflect on the implications it has for their actions.

Study Limitations and Ongoing Work

We worked with a small number of participants, which allowed us to collect detailed data but limits the generalisability of our findings. However, the fact that our results largely replicate research reports with adults, suggests that the issues we have identified as those which are an important focus are applicable beyond our sample. We are continuing our work with the same group and engaging with a second group of teenagers. In the second cycle of Phase 1 of the EoR we are presenting and discussing our analysis of the data with the participants. Through this participatory process of involving the teenagers in the design, we will ensure that the learning technologies we develop will focus on the resources that are most relevant and engaging to the learners.

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