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In its first five years, the Journal logged over five million page views and almost one million downloads of Acrobat files of monthly journals and eBooks.

Editor's Note: This is a simple and effective example of social engineering. Intrinsic motivation is used to focus the goal, and external feedback is provided my real and symbolic measures.

How Does a Visual Monitoring System Foster Sustainable Behavior?

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Abstract

Americans spend upwards of 90% of each day in buildings that account for two-thirds of electricity usage. Because the supply of smart buildings will take time to catch up with demand, efforts are sought to develop informed and educated people to live and work in these "dumb" buildings. Additionally, energy efficiency alone may be inadequate to achieve major reduction in carbon emissions (Darby, 2006). Finding ways to intentionally change the lifestyle behavior in a household should have significant implications in reducing environmental impacts as fossil energy use in resident homes is directly related to the exploitation of natural resources and a leading cause of air pollution and global warming (Poortinga, p 71). This paper attempts to understand how visual monitoring systems can be used by communities to assist in identifying and modifying collective and individual behaviors that result in reduced energy use. Specifically, the paper is a case study of a community of undergraduates on a Midwestern US college campus who have experience with three types of equipment that monitor and display information regarding energy use. Understanding user experience within the Campus Resource Monitoring system at Oberlin College in Ohio, this study explores intentional lifestyle modification for sustainable behavior through the use of technology, complemented by competition and educational programming. The findings are threefold. First, the prime motivating factor for participation in the contest was not a prize, as might be expected, but maintaining social networks. Second, the technology prompted the students to be more concerned about their direct personal impact rather than their aggregate energy use. Third, several students replied that the technology influenced them to self-reflect, and in so doing, they changed their ideas about what it means to be an environmentalist.

Keywords: environmental sustainability, learning, learning communities, ethnography, qualitative communities

Research Background

The goal of the research is to study communities that have strong relationships. This study uses ethnographic research to assess the role of a real-time feedback mechanism in the learning of environmental sustainability. Users of the product are important actors in this study and to explore this concept, we looked into studies in human-computer interaction (HCI). Several studies demonstrate that technology can positively influence human behavior in regards to more environmentally sustainable behavior. (Buys, 2005; Egan 2008; Foth, 2008). Mackay, et al. simply define users as "boundary label to delineate developers from others." From a list of Mackay's typology of users, this paper will focus on 'end users,' or operatives, as opposed to 'clients,' who are the universe of all for whom the system is intended and designed. The reason for this is because the system has simply not evolved to the full involvement of clients. Dobbyn and Thomas (2005) put it clearly:

> "Energy and power are not terms within the natural language of mainstream householders. Gas and electricity operate at the level of the subconscious within the home É. Whilst there does seem to be some latent cultural guilt about the notion of

> waste É, there appeared to be virtually no sense of being able to actively and significantly reduce energy consumption in the household."

Finding the "right user" who can not only provide an account of experiencing the product but also a knowledgeable critique about its shortcomings is a project discussed in user-centered design literature. Mackay and others call for a much more fluid definition of the notion of user in relation to designers and address the limitations of user involvement. Users are sought who can be reflective and critical.

Several types of feedback mechanisms, from billing to household devices to ambient orbs, have been studied to understand their effects on lifestyle modification. (Clark, 2003; Dourish, 2008; Fischer, 2004; Lysecky, 2006; Nawyn, 2006). Sarah Darby gives an excellent synopsis of worldwide experiences in energy use feedback mechanisms since they first appeared in the early 1970s. One common theme she finds is that there was a general consensus that feedback does in fact have measurable effects worth pursuing. "Overall, the literature demonstrates that clear feedback is a necessary element in learning how to control fuel use more effectively over a long period of time and that instantaneous direct feedback in combination with frequent, accurate billing (a form of indirect feedback) is needed as a basis for sustained demand reduction. Thus feedback is useful on its own as a self-teaching tool. It is also clear that it improves the effectiveness of other information and advice in achieving better understanding and control of energy use." (Darby, 2006: 3) In her analysis of systems used throughout the world that use direct (i.e., displays) and indirect (i.e., billing) feedback, direct feedback typically contributes 5-15% savings while indirect feedback has been shown to account for 0-15% savings. However, she cautions against saying that any type of feedback, regardless of the social context, will always produce positive results. (Darby, 2006: 7). What the social context might contribute to variability in results has yet to be explored, and is a gap that the current research seeks to explain.

Research Method

Due to reasons described above, and the dynamic nature they bring to the continued development of this innovation, advanced users are sought as a small convenience sample. Although they occur infrequently, advanced users are preferable because they are conceptually significant in that they are unusual in population but we can expect the same behavior from any other group with similar dynamics and constraints. This paper is an attempt to understand the structure of the common identity that lies beneath individual response. Efforts will be made to ensure that the sample contains adequate range on critically important dimensions.

This study specifically looks at a monitoring system that incorporates three different types of feedback mechanisms to motivate users to consume less energy. It has already been demonstrated that the system has in fact produced measurable results but the social context has yet to be explored (Peterson, et al 2005 and 2007). In 2005, Oberlin College installed "Dashboard," a real-time feedback monitoring system developed by Lucid Design Group in San Francisco, CA. (www.oberlin.edu/dormenergy/). The system is linked to public displays that feature touch screen interactivity as well as a website that displays energy use by dorm and by the college as a whole. Each spring, the college organizes a competition between dorms to promote the concept of using the technology and to learn about the energy footprint of their behaviors. Ambient displays, known as orbs, have also been installed in some resident halls that glow green if their dorm's energy usage decreased in relation to the same time in the previous week, yellow if it is the same, red if it is has increased.

Students were recruited using a snowball sample through the use of informants. Contacts were made with Lucid Design (the designers) and with an Environmental Science professor at Oberlin

College who identified advanced users. Oberlin offers an Environmental Science course which leads the Dorm Energy competition. Students were recruited from that class as well as those employed as student workers who operate and maintain the equipment. Those students were asked to recruit others. Students were chosen based on their level of experience with the equipment, the competition and educational programming. Eligibility criteria included: the student must have lived in a dorm during a competition, must have visited the website at least once and/or has used the public display and must have participated in an educational programming activity (enrollment in an Environmental Science course, participation with the Light Bulb Exchange, work as a Resident Assistant, etc.).

Figure 1. MIT Mobile Lab.

Oberlin College's enrollment for 2008 consists of 2800 students, 2200 in the Arts and Sciences, 600 in the Conservatory of Music, and 200 enrolled in the double degree option. Advanced users are likely to be enrolled in the Arts and Sciences or double degree programs, so efforts will be made to focus on these groups. Geographically, Oberlin students come from 9% in-state and 85% out of state, while 7% are from abroad. 54% of Oberlin students are female while 46% are male. (http://new.oberlin.edu/arts-and-sciences/at-a-glance.dot).

This case is appropriate because it is the only community in the U.S. who has had this system installed, working and linked to competition and educational programming for more than one year. While other college campuses have purchased some Lucid Design equipment, only two other colleges have enough equipment to attempt community involvement activities like competitions (Hamilton College, fall 2008 and University of Colorado Boulder, spring 2009). Harvard University, for example, has purchased one Lucid Design monitor for one of their graduate dorms.

Data Collection and Analysis

The semi-structured interview consisted of questions that attempted to assess how the subject understands the technology, his or her frequency and extent of use, her or his perceptions of its impact on their behavior and his or her perceptions of other factors that influence her or his behavior, especially focused on social networks and environmental education. The analysis used issued-focused coding and sorting in the following categories: attitudes towards community, individual behavior change, shares responsibility for environmental impact, lifecycle process of environmental awareness, technology, educational programs, perceived influence over other people's behavior change, attempted influence over other people's behavior change, coordination and competition.

The nine students interviewed at Oberlin range from freshman to senior - four females, five males, all American citizens. Several students were able to compare differences between dorms and

between on-campus and off-campus use. For example, one student has had experience with living in three separate dorms plus an on-campus co-op where there is an orb that displays performance. Between the three dorms, she noticed that the freshman seemed to be the most involved in the competition. Another student lived in the dorms, but now rents off campus. He reports that his experience with the system gave him the foundational knowledge so that when he moved out he could save money on gas and electricity. Students generally live in on-campus housing for much of their undergraduate career, but change dorms year-to-year.

Results

The findings of this study are threefold:

1. The prime motivating factor for participation in the contest was not a prize, as might be expected, but maintaining social networks.
2. The technology prompted the students to be more concerned about their direct personal impact rather than their aggregate energy use.
3. Several students replied that the technology influenced them to self-reflect, and in so doing, they changed their ideas about what it means to be an environmentalist.

Motivation

Oberlin conducts a competition each spring to reward the dorm that shows the biggest percent reduction of energy use. The interviewees were involved in the competition although they couldn't remember what the prize was and didn't remember hearing who won. A junior explains: "I think there was a prize for whatever dorm won, but I don't remember what it was. I think there was an ice cream party for whatever dorm won. But I don't think it was widely known. I think whatever dorm ended up winning, they all knew because they had an ice cream party or their RA sent them an email. I'm motivated to turn off the lights anyway. The competition doesn't affect me that much." One student said "I think we ended up winning, I'm not sure." Another said, "It wasn't that big of a deal who won." This finding suggests that the traditional motivator of a tangible incentive was an insignificant. Social networks are important and all of the students interviewed spoke about their influence on others. Many mention that they have used their knowledge to educate their parents about recycling, composting and gardening. A female sophomore mentions: "My mom, we also started saving rinse water from our washing machine and bailing it back into the next wash and we actually did see a very concrete result, the bills went down." Many talk to their friends about turning off the lights and turning down the thermostat. Some report resistance from others, some report acceptance and even appreciation from others when sharing suggestions on lifestyle behaviors.

The subjects also appreciated the efforts of others and acknowledged how others acted as leaders in the competition. Almost all students reported that the buy-in of the Residence Assistants (RAs) was imperative to motivating their charges in changing their behavior. Many students suggested that the RAs who built community through dorm meetings were more successful than those who did not.

Consumption Patterns

Students seem to develop a hierarchy of actions that they employ. For instance, at the top of their list might be that they turn off the lights when they leave the room even when there are no tangible incentives (prizes or financial savings) while other behaviors at the bottom of the list are only employed when there is an incentive to do so. "Living in [a freshman dorm], we had a very close atmosphere and it was more a let's do it and try to win the energy competition so that was more like people were turning out all the lights in the hallways which I mean was great except

that you couldn't see and you walked into other people." Other dorms unplugged the vending machines to win the competition; some students save water by going to other dorms to do laundry. One student reported that his roommates put a picture of John Edwards in the shower to discourage people from staying the shower too long.

Most of the behavior changes in this category on their hierarchy occur during the competition and taper off afterwards. This hierarchy is both personal and informed by social factors. For instance, students who lived in a particular residence that were selected through an application process based on their environmental awareness, the hierarchy included everyday actions such as collecting gray water from sinks and laundry that was more extensive that others who lived in mixed residencies. The monitoring data shows that energy use is reduced in the competing dorms through the end of the semester and only returns to baseline when students return the following year.

Retro-effect

Self-perception changes and matures as students are exposed to environmental information. Students report that their involvement in the competition and their use of the Campus Resource Monitoring system is heavily influenced by an evolution of awareness of environmental issues. When asked if they thought they were environmentalists, many students nodded in affirmation, with hesitation. When asked if they thought they were environmentalists before the competition, several students explained that they thought they were environmentalists in high school, but as they learned more about their impact on the earth, they realized that their actions were not so environmentally friendly. Socialization as a child to connect with nature, environmentally focused courses at Oberlin, and the liberal atmosphere of the college were mentioned by students as factors that lead them to use the technology to its fullest extent. "Even though I grew up being energy conscious, my environmental awareness increased as I was on campus longer. I paid more attention to this type of thing in later years than, say freshman and sophomore year." They see the real-time feedback mechanism as a feature that expands their knowledge of their personal impact on the environment that could helps others in the same way.

Conclusion

In all, students are positive about the system. They like the fact that the large monitor is easy to use and reminds them to go to the website. Students report that they are slightly emotionally involved with the results. For example, seeing an orb glowing green made one student feel "proud" and "satisfied." The publicity about the competition and RAs as social leaders is very important in reminding students to change their behavior. The students would like even more direct feedback - the system today only gives floor by floor or dorm by dorm analysis but not room by room. They say they do not know the direct impact of their action, but they perceive that it makes a difference so they continue doing it. One senior says: "A lot of people talking about the lack of control which was related to heating. In some of the large dorms you have absolutely no control and then sometimes in the older buildings you got too hot and you open your window in the middle of winter. But most of the heat is generated by burning coal and creating steam and it's like it's not where our heat comes in is not set up particularly well for individual adjustments." Another Oberlin senior explains, "I think the competition and the orbs are a step in the right direction. But the more specific things are the more personal the better, I think people will respond." If the system is improved to provide even more immediate and concrete results, they say that this could have positive implications in motivating people to reduce their energy and water use.

This paper seeks to inform models of lifestyle change through advanced technology, using real-time feedback on energy use. The literature suggests that end users modify their behavior

when exposed to such information. The analysis suggests that real-time feedback one factor of many in modifying behavior for advanced, well-informed users but may be more important in reminding users to continue habits. This study shows that a visual monitoring system can support sustainable behavior if the users are motivated through social networks and if the technology is tailored to individuals so they better self-reflect and experiment with their behavior.

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Appendix - Interview Questions

1. In your own words, can you describe what the Campus Resource Monitoring is? What is involved?
2. When was the last time you used the monitor? website? Did you live in a dorm with an orb? Did you feel your actions had an impact on the data that was being monitored? If so, how did you know that?
3. What are some actions that you had to do in order to win the competition? Do you still do those things now that the competition is over? Why or why not?
4. Did you have a "eureka moment" when you figured out what do you had to do to win the competition or reduce your energy/water consumption? If so, can you explain what happened?
5. What are some factors that influenced you to change your behavior?
6. What are some factors about the website/monitoring system that influenced you to change your behavior (i.e., icons, mouse clicks, etc.)?
7. Before this project, did you consider yourself to be an environmentally friendly person in relation to your friends/peer group? Do you now?
8. Do you talk about this project with others (friends, family)? Why or why not? How do they react?

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