Emotionally Engaging Students to Change Behaviors and Conserve Resources: Unplug or the Polar Bear Gets It!

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ABSTRACT

Our goal is to make an emotional connection between individual energy use and its impact on the environment in order to motivate people to change their behavior and conserve resources. TellEmotion's unique method for displaying real-time energy use information combines research in the areas of behavioral sciences, sociology, information visualization, computer science and interaction design to motivate energy efficiency. In its simplest form, we begin with an animated polar bear. When energy use is low, the bear is happy; when it is high, the health and happiness of the bear is endangered.

In this paper we present recent findings from implementations in two school settings: Brooks School (a boarding high school in N. Andover, MA) and Dartmouth College (in Hanover, NH) during the spring term of 2009. Electricity reduction from the implementation of TellEmotion's ***GreenLite System***, averaged between 10 and 11% for a six-week period, with one dorm in each school reducing electricity use by as much as 34%. In both settings, students quickly "fell in love" with the bear, named her ("Bula" at Dartmouth and "Pasha" at Brooks), sent emails to their friends to turn things off to save the bear when energy use was high and remained motivated and engaged over the length of our trials, with reductions even improving over time at Brooks. There were no other incentives in place to encourage students to reduce electricity use and no physical energy efficiency improvements made during the trial period.

Introduction

The globe isn't just warming; it is overheating. While supply side and technological innovations are critical, behavior has become increasingly important in the fight against global warming and the pursuit of a sustainable energy future (Randall & Schwartz 2003: Kiner). Because energy use behavior can be influenced by factors such as age, culture and upbringing, it is something that can be reshaped through education. In fact, many experts now consider behavior as the "primary lens" through which to study energy efficiency. (Efficiency 2.0)

Behavior also has the potential to deliver significant effects relatively quickly and at a lower cost than most technology solutions**.** Energy efficiency provides a vast, low-cost resource of energy that people all over the world can tap into. (McKinsey 2007) In fact, Lisa Margonelli, journalist and Director of the Energy Policy Initiative at the New America Foundation, maintains that streamlining our energy use is equivalent to finding a new energy "gusher". (Margonelli 2008) But even though energy efficiency behavior could be powerful in solving many of our climate change problems, it is extremely difficult to motivate people to change their behavior when the effects of climate change are still in the future, the effects are relatively slow and CO_2 increases are mostly invisible. (Weber, 2009: Loewenstein, Weber & Hsee 2001)

Some open questions our work addresses are:

- Does an emotional connection to data persuade people to change behavior?
- Can we convey data visually in such a way that it creates an emotional connection to the data?
- Will this emotional connection motivate behavior change (energy efficient operational and purchasing behavior),
- Can this approach work with a group that has no financial stake in its energy use?
- Can we sustain the behavior change over time?

Behavior Change: An Overview

While much is known about behavior as it relates to economics, health and consumer trends, applying behavioral studies to sustainability is a relatively recent endeavor. We attempt to answer our research objectives by approaching the process of changing behavior through five key elements: feedback, information, control, motivation, and engagement.

Feedback

Systems dynamics and multiple studies have shown that feedback is effective in creating behavioral changes and real-time feedback is the most effective (Holmes 2007). We can use a very simple example to demonstrate our thinking: an interactive display by the road showing—in real-time—your current speed next to a smaller sign listing the speed limit. While it is possible to pass these roadside monitors without reacting, nearly all of us respond by looking at the sign, checking to see if we are going slowly enough and adjusting our speed accordingly. Because the feedback is in real-time, we can easily equate our actions (slowing down) with the feedback (the speed changes on the sign). This gives the feedback system more weight because it is clearly reflecting our behavior and we believe it to be an accurate representation of our behavior as a result. Currently, students receive no feedback at all about their energy use on campus.

Information

In order to change behavior, we need enough information about the current behavior and the desired behavior to make an informed decision. Using the roadside example from above, we are given enough information to make a "good" choice. We know:

- Our current speed
- The target speed (the speed limit)
- What to do to change our current speed to match the target (ease up on the gas)
- What the consequences could be if we don't make the change (a ticket)

Similarly, easy to access information about current energy use, a target level of energy use to aim for, behaviors that contribute to high use that can be easily changed, and the consequences of high energy use, would help energy consumers be more efficient.

Control

Just as a passenger in the car (who cannot affect the speed) is not influenced by the interactive speed sign, students who cannot alter automated energy systems (lights on a timer, automatic thermostat settings, etc) will not be motivated to conserve energy. It is important, therefore, that we create a feedback system for measuring energy use that is under the control of the group we are hoping to influence.

Motivation

Motivation is a key element for behavior change and one that has been particularly difficult to elicit in most Americans when it comes to climate change. The driver in our example is motivated by the fear of a ticket, the costs associated with a ticket, and the inconvenience of being pulled over. How can we motivate students to reduce energy use if they have no financial consequences associated with energy use behavior? They do not receive a bill every month, nor do they see their tuition increasing or decreasing as a result of energy use behavior. To address this dilemma, many schools participate in short-term competitions, lasting two to four weeks, in which the dorm that reduces energy use the most during that time receives a prize. We believe these short-term events don't create the desired long-term behavior changes and are relatively easy to "game." While a deep concern for the state of the environment is enough to motivate some students, the challenge is to motivate students for whom this might not be enough. We want to take average students or non-believers and motivate them to change behavior and change their attitude along with it, while inspiring those who already conserve to keep up the good work, motivate others and improve on their own results.

Engagement

If you are texting when you pass the speed sign, you won't change your behavior because you are not engaged. Similarly, if you get away with speeding so many times that you no longer feel motivated by the threat of the ticket, you may not stay engaged enough to continue to match your speed to the speed limit. Engaging people over long periods of time and sustaining behavior changes is a big challenge. An example of this is the short-term dorm competitions in which students are rewarded for conserving the most electricity over a two-week period. The results are dramatic, but there is little or no residual effect (Peterson 2009). Climate change is a long-term issue that will require sustained shifts in energy use behavior.

CURRENT APPROACHES

Feedback, control and information are aspects of efforts by a burgeoning selection of companies working to change energy use behavior in homes, businesses and educational institutions. The goal of these systems is generally to motivate the behavior change through information on pricing and current use. Methods include dashboards displaying charts and graphs, orbs and emoticons. Lucid Design Group, Google Dashboard, GreenBox and AgilWave, for example, use real-time feedback from digital meters, to provide data for their web-based dashboards.

Smart grid deployment brings the acceleration of new technologies for in-home devices, home area networks, demand response and load shedding technologies in the residential space. These systems also utilize charts and graphs as the interface for providing energy information, see **Figure 1**. Some researchers have identified the value of "emoticons" placed on utility bills (Schultz, Nolan and Cialdini 2007) This has been the basis of pilots in the Sacramento area and the foundation of O-Power (formerly Positive Energy). **Figure 2**.

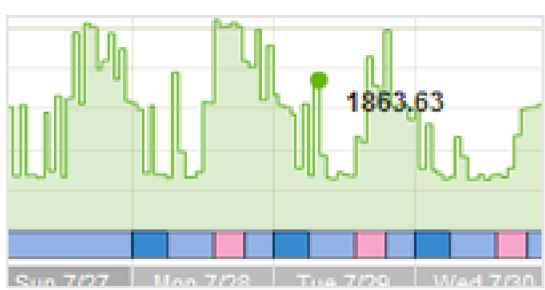

Figure 1: GreenBox's display of energy use in a home.

Figure 2: O-Power's Feedback system compares residents to others and fosters an emotional response through competition.

Ambient Orbs are also used to create an impossible-to-ignore reminder of energy use. The orb's color changes to reflect energy use (green is good, red is bad) or to show peak use pricing. Studies by EPRI (Electric Power Research Institute), as presented at an ACEEE (American Council for an Energy Efficient Economy) conference in March 2009, showed a large disparity in results but most seemed to average a reduction of less than5% (Robinson 2009). One of the gaps identified in the same study was a lack of information about demographics beyond homeowners and bill payers in pilot studies (Robinson 2009).

OUR WORK

Our work utilizes feedback, control, information, motivation, and engagement to encourage resource conservation and efficiency behavior in educational institutions. We focus our efforts on motivation and engagement, as we believe these to be critical elements in behavior change. We begin with a polar bear. When electricity use is low, the polar bear is happy; as use increases, the bear's health and happiness are endangered, **Figures 3 & 4**.

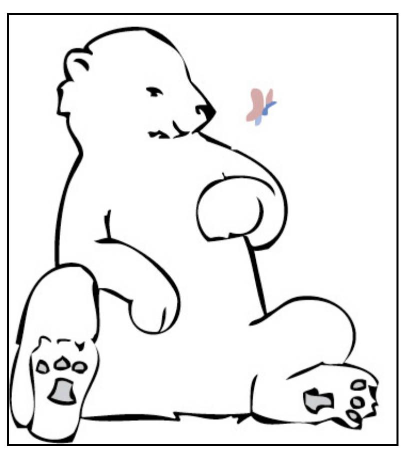

Figure 3: Happy 2D Bear

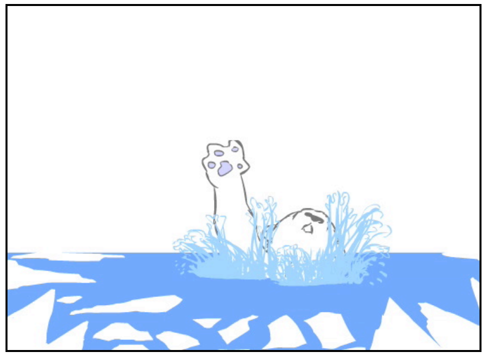

Figure 4: Distressed 2D Bear

We use a "mood" algorithm to determine which animation to call up, based on predictions of what energy use should be at a particular time and day. At Dartmouth College, we use a mix of low-energy displays in dormitory halls, a website, and a desktop widget to display our content. We chose the polar bear as the first character for the animation because it is an animal whose existence is significantly impacted by climate change. In our animated world, the actions of the bear reflect the amount of energy being used; to keep the bear safe and happy, dorm power use must improve. With just a quick glance, students can monitor the polar bear's state and instantly be informed about their energy impact without having to ponder any difficult graphs or try to decipher scientific units. Furthermore, using the touch screen display, **[Figure 5]** students can instantly monitor the energy levels on their classmates' floors, a feature which gives students an incentive for competition towards even greater energy reductions. We supplement the animation with text and images about a user's goals, progress towards these goals, tips for reducing energy use and information about current energy use. Every Monday, new comic strips are displayed on the kiosk, website and in print, to keep students engaged in the data. We are developing a 3D game in which students work together towards shared goals in order to bring a bear cub and her mother together again **[Figure 6]**.

Figure 5 Touchscreen displays are placed in dorm hallways. Custom motion detection software turns kiosks off when not in use to save energy.

Figure 6: A 3D mother bear watches as her cub floats away. Students can bring the mother and cub together by reaching shared group goals. © TellEmotion 2009

Method: The Technical Set-Up

TellEmotion's "GreenLite" feedback system is based on five components: polling of real-time energy data, data aggregation, data analysis, visualization content, and multimodal display.

We poll digital electricity meters for data several times per minute and store the data in our database. We utilize a variety of commercially available meters with both wired and wireless communication. We can get data through modbus, xml, or zigbee communication protocols. We place meters at a resolution that is fine enough to measure small changes in electricity use but large enough to maximize efficacy by motivating people towards common goals. We measure those resources dorm residents use directly—lighting and plug load—avoiding those resources the students do not control. In addition to electricity, we collect data on heat, water, and hot water in some dorms, as well as college-wide printer usage. Data becomes available to our web-application within seconds, providing an essentially real-time experience. If meters don't collect data that often, we can adjust our poller. API's connect our database to building management systems.

We compute one-minute averages of power consumption data and store these averages in our database for analysis and graph generation. In addition, we aggregate data from several meters together to compute power consumption at building and campus-wide levels. Data aggregation is controlled through an aggregation hierarchy shown in **Figure 7**. Electricity data from the leaf-nodes in the hierarchy "sum-up" to the parent nodes.

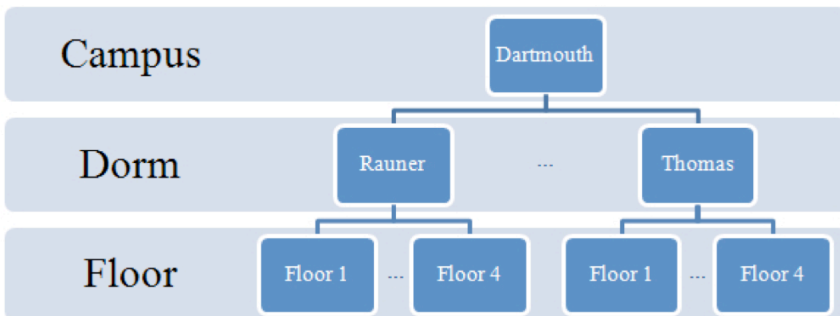

Figure 7: Our hierarchical node structure

Various "mood algorithms" analyze the data and determine the current animation. In our initial implementation, four discrete animations show the bear in various stages of distress. We also show additional statistics (such as daily and weekly trends) on the side of the screen. A forthcoming version of the animation will incorporate the additional information directly into the animated scene. In this forthcoming version, short-term power consumption trends drive the bear's actions while long-term trends control the state of the bear's environment as well as his health. We apply a "mood algorithm" to analyze current (real-time) power consumption and compute our short-term score. To determine the score for a particular Wednesday at noon, we build a histogram of power data from previous Wednesdays collected between noon−x minutes and noon+x minutes, where x is typically about 301. We use the histogram to compute a probability statistic for the current power consumption value and use this statistic to drive the animation. As noted above, we also compute long-term mood scores such as the daily, weekly, and monthly change in power consumption and make these statistics available to the front end. Our server can use per-person usage statistics rather than total usage statistics at the option of the administrator.

We are developing three-dimensional animations using motion capture and Autodesk Maya [**Figure 6**]. At runtime, the animations play in the powerful Unity3D browser plug-in; we also have a flash version of the animations. We script various interactive interface elements using Unity3D. A Google Web Toolkit (GWT) - generated JavaScript application program controls additional elements of our site, such as the graph interface and RPC plumbing, which obtains data from our server. We implemented the backend using Java Servlets (deployed in Apache Tomcat) on top of MySQL.

We strive to turn energy use data into a meaningful real-time, interactive story. We utilize either Flash or a 3D animation/game engine to create the animations. Everything in the interface content reflects real-time data:

- An animated character's health and happiness depends on students reducing energy use.
- The animated environment reflects long-term goals and success in achieving those goals. With electricity, for example, at the beginning of the term the environment is in trouble. As students make progress towards their goal (set by either an administrator or the user), the environment improves.
- Time of day (and weather) are reflected in the display to reinforce the connection between the user's[1] world and the animated world. Similarly, the display reflects real-world changes between night and day.
- Animations reflect the specific energy source. Dartmouth generates heat with oil and the animated environment is that of an oil field; thus electricity use is displayed through a polar bear in the Arctic. We use animations of trees being cut down to reflect paper use on campus.
- Graphs show additional detail over varying lengths of time (recent, hourly, weekly, monthly) and compare current use to historical data to put the chart into context, so that users can understand how they are doing relative to the norm.

Kiosks are placed strategically throughout the campus: in dorm halls, in the dining area, science centers and administrative offices. Kiosks are set to display the web portal view for that dorm or, in public spots, for the aggregated campus energy use. The monitors are Energy Star touch screen computers with custom motion detection software installed to turn off the displays when not in use.

OUR "SECRET SAUCE"

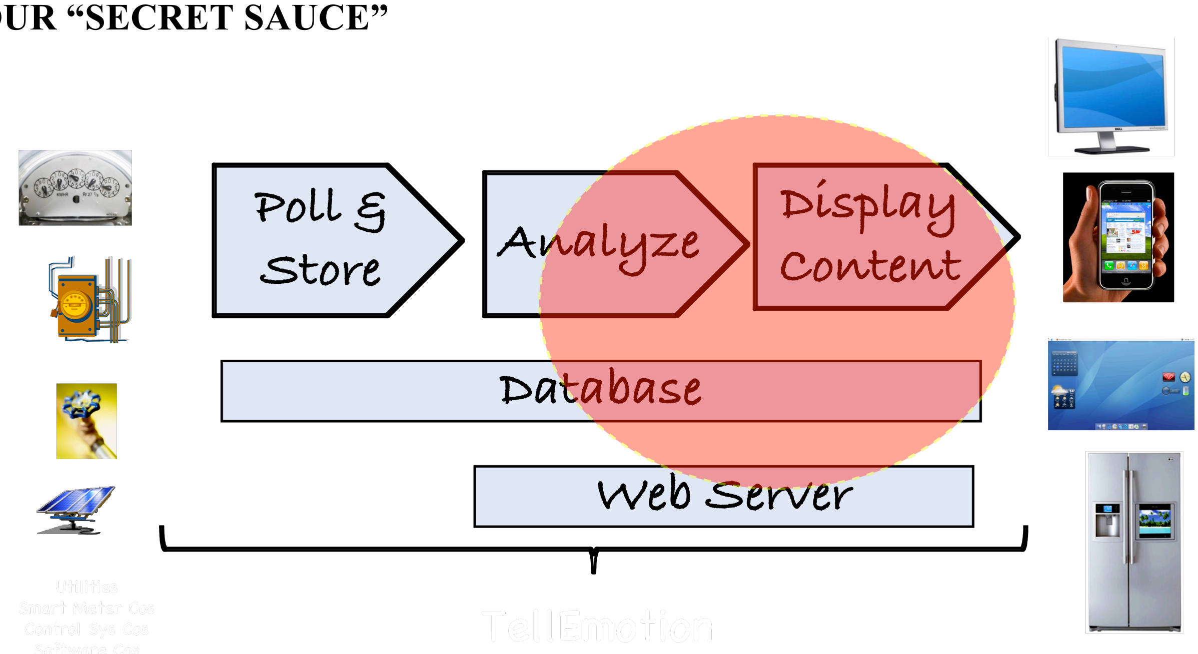

Figure 8: The TellEmotion "GreenLite" system focuses on the interface between the data and the consumer

[1] When a week's worth of data is not available we hold constant time, but use data from different days. When a day's worth of data is not available, we use data from the previous hours.

Our goal is to create an emotional connection between the individual energy user and the impact of his or her actions on energy use in the dorm. Once students feel connected to the animated bear, they also begin to feel the actual impact of their individual actions on real polar bears as they struggle to survive the effects of climate change. The user's daily activities become intertwined with the polar bear's well being, and the two become protagonists in a larger story. Social scientists have found that involving individuals in a "story" can be especially effective for transmitting core values that can spur the adoption of new ways of thinking **(Sachs)** Our results confirmed that this leap in understanding helps shrink the otherwise vast chasm between daily actions and the effects of climate change. One Dartmouth student said, "I never thought of myself as an environmentalist, but now I do. I don't want Bula to drown."

Not only are students learning about the impact of individual actions on the environment, but they also begin to understand how group action exponentially increases small effects. By metering a group's energy use and displaying it together, as well as setting collective energy use targets, students begin to understand the importance of working together towards common goals. They also enjoy the group interaction that comes with the system: emailing and texting each other when the bear is in trouble to suggest turning things off; holding meetings by candlelight and celebrating the joy of beating other dorms at reducing the most electricity.

In addition, it is easy to understand that if the bear is flailing in the water, you are not doing well on energy conservation. By making complex data easy to understand, we hope to improve results.

Why target schools?

Most pilot projects studying electricity feedback and behavior are focused on residential applications. This study looks at the school setting for several reasons:

- Students currently receive no feedback about their energy use;
- We are interested in the unique challenge posed by a "customer" who experiences no financial ramifications from changes in electricity use;
- The core value of the institution is education and our system offers many educational opportunities;
- Students cycle through a school, with new students coming into the system every year which offers opportunities to reach large groups of people and create leaders among the juniors and seniors;
- Students naturally form into social groups—by dorm, by year, by interest—allowing us to create multiple groups working together towards energy goals and creates opportunities for competitions between groups;
- Schools have relatively large annual energy costs;
- Dormitory settings offer many opportunities for energy use improvements;
- Students move between buildings throughout the day offering multiple opportunites for them to view kiosks and gives students who aren't in "GreenLite Dorms" an opportunity to participate;
- Our system can integrate with existing sustainability efforts and goals in a school setting;
- Many schools and colleges are already participating in CO_2 reduction efforts, pledges, and rating systems; this program supports and enhances existing programs.

For the 2008 fiscal year, Dartmouth's energy consumption totaled 65,400 megawatt- hours. In that year alone five million gallons of residual oil were purchased to fuel the Dartmouth Power Plant. It was felt that reductions in campus energy use would bring huge environmental and financial benefits to the College.

In September 2008, Dartmouth committed to a greenhouse gas reduction program that would reduce 2005 campus emissions by 20% in 2015, 25% in 2020, and 30% in 2030. However, a new energy strategy for achieving these goals has not yet been defined. An important step towards reducing campus emissions is educating students to conserve. This is where the TellEmotion "GreenLite" interface comes into play. Our research has shown that if students always made environmentally conscious decisions, campus energy use could decrease up to 20% without any significant change to infrastructure. Given that most campus energy sinks (such as heating and cooling) are fixed, it is remarkable that a simple student action can have a visible effect on college- wide energy use. As a result TellEmotion, a project that targets behavior, has enormous potential not only for Dartmouth but for other higher education institutions. Dartmouth could encourage other colleges to set up feedback systems and challenge those schools to see which campus achieves a lower carbon footprint. By playing on school spirit and pride, Dartmouth could help lower energy use across all college campuses in America.

RESULTS

Dartmouth College Implementation and Results

In the Spring of 2008, we launched a GreenLite pilot in two dorms floors with 56 students. Over the pilot project study period of two months, we measured reductions of 22% and 14% from a combination of plug-load and lighting in dormitory floors with TellEmotion GreenLite system installed. These results were significant compared to other real-time display systems, especially considering that we only measure a portion of the total electricity use in the buildings.

In Spring 2009, we expanded to 11 dormitories, including one sorority and one affinity house. Over a two-month period, we observed reductions averaging 10% in energy use. In addition, student surveys and focus groups emphasized the positive social impacts: 80% of students in "GreenLite Dorms" said they looked at the kiosk displays regularly to see how they were doing; a total of 68% of students surveyed, reported that our display made them more energy conscious (a significant shift as focus groups prior to the implementation of the TellEmotion GreenLite system reported that 64% did not think much about the environment or take action to conserve resources beyond recycling). In 48% of cases, students took steps to lessen their environmental impact in areas not metered by TellEmotion. Students explained, for example, that the information caused them to switch to using drying racks on a regular basis instead of electric clothes dryers, take shorter showers or recycle more.

The Brooks School Implementation and Results

The TellEmotion system was implemented at the Brooks School, a preparatory high school in Massachusetts, with boarding and day school students, during the spring of 2009. A kiosk displaying the Flash animations and competition status was implemented into each of the 10 dorm buildings. The system immediately garnered the support of students, parents, and faculty. Students began sharing the energy conserving habits they learned at school with their families at home. Teachers expressed confidence that teaching this information at a young age will help the students retain this knowledge in the future. In fact, research shows that children form their belief system between the ages of 9 and 11 and these beliefs are cemented by the age of 20 and these beliefs are heavily influenced social messages. (Gimpel, Lay and Schuknecht) Faculty and administration at Brooks School reported an enthusiasm among students for energy efficiency as a result of the animated display and connection to the bear. Dean Ellerton, the CIO of Brooks School wrote, "I should tell you that our kids are pretty excited. So far, this has greatly exceeded even my most optimistic forecasting. Everywhere I go on campus, it's all people want to talk about." (Ellerton)

Figure 9 shows the one-month energy reductions for each of the 10 dorm buildings. Energy measurements were taken during a 4-week period immediately prior to the implementation and averaged to establish a baseline. Identical measurements were taken during the 4 weeks immediately following the implementation and averaged to establish the level of improvement. This conservative reporting approach assumes that savings were constant throughout the 4-week reporting period when in fact most dorms showed improving results during the 4-week period. As an example, the Hettinger East dorm demonstrated steady improvement throughout the 4-week period with 16.6% savings during the final week vs. the 12.2% savings shown in **Figure 9**.

The implementation at the Brooks School occurred late in the school year, precluding us from measuring results over a longer time period. Brooks School will be re-launching the system in early December, 2009 and we hope to present the results from this additional time period during the February 2010 AESP meeting.

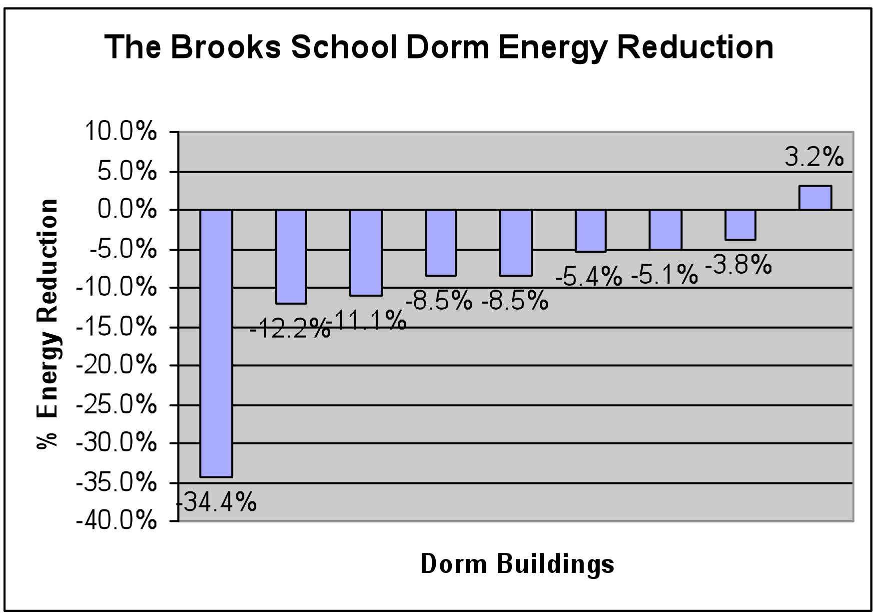

Figure 9 Energy Reduction at the Brooks School

Analysis: The User Studies at Dartmouth

In our most recent expansion of the system at Dartmouth, which occurred in Spring 2009, we were interested in exploring student responses to the system. Although the reductions in energy use were encouraging, we wanted to gain insight into the student thought process that ultimately made these reductions possible. As a result, we decided to map out a three-stage procedure. At first, we did a preliminary study to "sound the waters" in the form of a survey asking students how they described their energy habits before TellEmotion was launched. The almost-unanimous response pointed to a lack of concern or awareness for energy consumption in daily activities. To explore this statement and TellEmotion's effect on the student body, we established focus groups made up of students who lived in dormitories where TellEmotion had been installed. During these meetings, the students were asked to elaborate on their experience with the system and offer any suggestions for improvement. In addition, we created an online survey, which generated 94 student responses. While answers varied, responses were largely positive and over 75% of the students reported that the system had encouraged them to adopt more energy efficient habits in the first few weeks of installation alone.

Although anecdotal, additional indicators of the power of this type of feedback interface include:

- An unsolicited cartoon in the Dartmouth student newspaper showing "Bula the Bear" drowning in beer during Green Key Weekend—a weekend in which students overindulge. **Figure 10**
- A Dartmouth student exclaiming in delight when she first sees the 3D animation, "Bula has a baby! Look everyone, Bula has a baby!"
- Brooks students reporting a significant increase in the number of students joining eco clubs and participating in environmental events.
- A viral reaction to a video story on the project by the Chronicle of Higher Education's Wired Campus. The story was one of the top five circulated stories and generated interest worldwide.
- Media interest in the project included articles on the AP wires, local television coverage, Newsweek and the National Wildlife Federation.

Discussion: Behavioral Implications

Through the user surveys and focus groups, we were able to explore the sociological aspects surrounding student energy use. As a result of our observations, we learned that targeting the "group" as opposed to the individual is a more effective way to spur environmentally friendly behavioral change. Again and again, surveyed students cited the importance of the floor dynamic in fueling their efforts to lessen their impact on the environment. Students were observed encouraging each other to turn off the lights or turn off a printer left on stand-by. The fact that the system makes floor energy use public to the entire floor and the rest of the Dartmouth community made it a point of pride for students to perform well and keep their electricity use low. Furthermore, the system effortlessly became part of the social interactions on the floor. Much like in the real world, where a single person's actions hold repercussions for the rest of the planet, students began to see the importance of a unified commitment to respecting the environment. Students mentioned that the system was particularly effective because it pushed them into taking an active role as a group, instead of targeting students individually. As a result, the success of the system is very much a testament to the power of the group and social communication in promoting change.

CONCLUSIONS

Through the installation of the TellEmotion GreenLite interface system, we have observed significant reductions in energy use as a result of changes in behavior. While the study is limited in scope, we had success in creating an emotional connection to the data and changing energy use behaviors. Reductions measured 9-10% at Dartmouth College and 11% at Brooks School. The system generated excitement and interest among students, and reductions have been steadily increasing. Students expressed feelings for the animated bear and a deepened emotional connection to the impacts of climate change on the environment—by changing behavior and creating an emotional connection to the real-time feedback data, student attitudes changed. Our data and our focus groups have confirmed initial expectations as to the value of personalized feedback, the importance of establishing an emotional connection with the user, and the centrality of group dynamics. Our reductions indicate that emotionally engaging energy feedback systems, such as GreenLite, hold potential for changing society's attitude towards the environment and reducing electricity expenditures significantly. In fact, if similar reductions were replicated across all K-12 and post-secondary schools in the country, our national electricity expenditures would fall by $860 million USD every year. (Environmental Protection Agency) But even more significant is the potential for influencing attitudes and behaviors of future generations through compelling feedback systems, installed in educational institutions, which are designed to emotionally engage youth, change social norms and encourage energy efficient behavior.

FUTURE DIRECTION

In the future we would like to:

- Study effects over a longer period of time to test the sustained effects;
- Conduct larger pilots for a more robust study sampling and to allow additional groupings and competitions. For example, additional implementation in colleges would allow Dartmouth to compete with Harvard, Brooks School to compete with Phillips Andover, Freshmen to compete with Seniors or the football team to compete with the rugby team;
- Create interfaces for additional resource use beyond electricity, such as water, heat or pounds of garbage;
- Continue to develop the game platform for online energy use games;
- Add to the social networking possibilities so that students can comment back to the system or interact with others through the interface and kiosks;
- Develop an iphone application;
- Develop additional characters and animations for displaying energy use and its impacts;
- Conduct pilots in commercial and residential settings.

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