Ghost Hunter: Parents and Children Playing Together to Learn about Energy Consumption

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ABSTRACT

We present the design and evaluation of Ghost Hunter, an interactive system to engage parents and children in seeking out *hidden* sources of energy consumption in their homes. Our system combines an electro-magnetic field (EMF) detector with a mobile tablet computer. Bringing Ghost Hunter within range of an electrical current activates the detector. Through the Ghost Hunter design we attempted to evoke the cultural form of hide-and-seek as a way to help children and parents structure their activity. We present our design and implementation followed by a qualitative evaluation conducted with seven families in their homes. Our findings describe how parents supported their children's learning about energy consumption, and ways in which the activities led to unexpected discoveries.

Author Keywords

Children; families; learning; cultural forms; sustainable interaction design; energy vampires; tangible interaction; eco-feedback.

ACM Classification Keywords

H.5.2. [Information Interface And Presentation]: User Interfaces – Interaction styles;

General Terms

Human Factors; Design.

INTRODUCTION

Helping families identify and reduce household energy consumption is a central goal of sustainable interaction design [2, 4, 6, 7, 8, 10, 12, 17, 23, 25]. In this paper we present the design and evaluation of *Ghost Hunter*, an interactive system to engage parents and children in informal learning activities in which they seek out hidden sources of energy consumption in their homes. Our system combines an electro-magnetic field (EMF) detector with a mobile tablet computer. Bringing Ghost Hunter within range of an electrical current activates the detector. Families use an app on the tablet computer to keep track of energy sources that they have discovered so far (Figures 1, 3, 4). For example, bringing the device within a few inches of a microwave oven on standby mode will make it vibrate and beep. However, the same microwave heating up food will activate our system from several feet away. To help facilitate productive family engagement we designed this system to evoke *cultural forms* [13] related to search games such as *hide-and-seek*, *scavenger hunt*, and I-*spy-with-my-little-eye*. All of these games involve people playing together to search through their environment for hidden things. This general activity structure seemed like a good starting point for the interactions that we were targeting.

While there has been growing interest in sustainable interaction design in the human-computer interaction community [4, 7, 10], the role of children has often been overlooked. In this work, our goal is not only to increase awareness of energy consumption in homes, but also to create opportunities for informal, intergenerational learning activities around issues of sustainability [12]. Our motivation for this undertaking is based on the assumption that it is important to involve kids in thinking about energy consumption at an early age—as children are the next generation of adults who will face increasingly difficult challenges related to energy, the environment, and climate change. More than this, however, we make the assumption that through interactions with other family members, children have a meaningful role to play in helping their families move toward more sustainable ways of living.

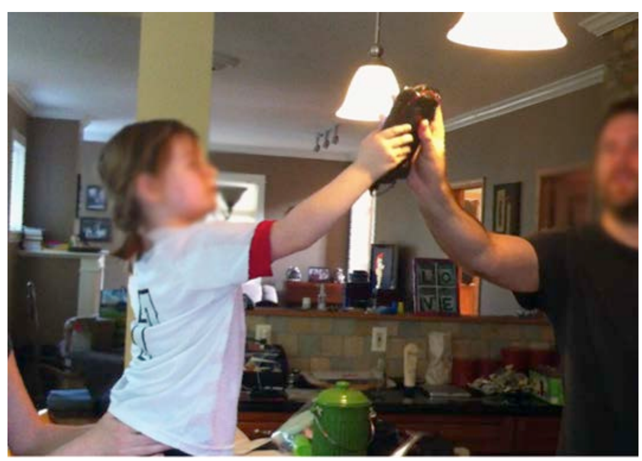

Figure 1. Family searching for sources of electricity consumption in their home using Ghost Hunter.

TEI'14, February 16–19, 2014, Munich, Germany.

In this paper, we briefly review some of the most closely related work along with the theoretical underpinnings of our design. We then present the design and implementation of the Ghost Hunter system followed by a qualitative evaluation conducted with seven families in their homes. Our findings elaborate on the ways in which parents support their children's learning about energy consumption, and how these activities lead to unexpected discoveries.

RELATED WORK

Ghost Hunter builds upon the following areas of previous research: (1) eco-feedback technology for homes and (2) playing to encourage pro-environmental behavior.

Eco-feedback technology for homes

According to Fitzpatrick and Smith, environmental sustainability begins at home [6]. Currently, energy consumption in homes is largely invisible; the energy delivery infrastructure conceals the intermediary steps such as mining, processing, and transmission. Thus, one goal of eco-feedback technology is to help make consumption more visible in terms of scale and impact [2].

There are numerous examples of research in the HCI community that aims to help connect people with resource consumption. With Upstream, Kuznetsov and Paulos use a traffic-signal based metaphor to convey water consumption [17]. Gustafson and Gyllensward presented a less literal eco-feedback technology called the Power Aware Cord that gives ambient feedback by visualizing the use of energy through glowing pulses and intensity of light [11].

More recently, with the Shower Calendar, Laschke et al. presented a concept aimed at reducing water consumption for showering [18]. A display installed in the shower showed dots that changed in size with the consumption of water. Froelich et al. took a broader look at water consumption by exploring eco-feedback designs based on data from fixture level sensors [8]. They emphasize the point that "eco-feedback displays do not just visualize consumption, they document *household activities*."

Many of the studies discussed above, along with the commercial products [22], focus on eco-feedback that assumes rational decision-making. Things like: "this is green, I should continue to do this", or "this number is very high, I should try to reduce it" are inherently less subtle and have the potential to break down as a paradigm because of social dynamics in a home. According to Strenger [25], current eco-feedback systems cast householders as "micro-resource managers" making rational choices; they do not take into account social or familial dynamics that can affect rationality. Similarly Pierce et al. [23] found that interactions with technology in the home are performed unconsciously, habitually, and are mostly irrational.

Designing for domestic sustainability, therefore, involves improving the visibility of resource consumption, addressing social dynamics of households, and working towards a shift in social and cultural values.

More importantly for us, most eco-feedback and management technologies tend to be adult-centric (with a few notable exceptions [e.g. 3, 27]). This is troubling because children, a segment of the population that could meaningfully contribute to resource management, are potentially being excluded. A good example of work that considers the role of children is Desjardins and Wakkary's study of opportunities to develop eco-feedback for children based on their understanding of sustainability and their own visualization of their homes [3].

Playing to encourage pro-environmental behavior.

The relationship between *play* as a learning mechanism and its potential for promoting pro-environment outlooks is interesting for this project. Play has long been explored from a sociological perspective. Huizinga [14] described play as a socially cultivated activity, where learning is undertaken without fear of any social repercussions. Huizinga's definition of play represented it as clearly structured and having elements of repetition and alternation. More recently in the HCI community, Gaver proposes a decoupling of the design of technology for work from those of play; designing for play is suggested as a means of promoting curiosity, wonder and reflection [9]. While Gaver borrows the term *homo ludens* from Huizinga, his stance is differs from Huizinga's due to its deliberate lack of structure. Using a situated messaging device called *Wayve*, Lindley et al. explored playfulness in a familial setting [20]. One of their conclusions mentions that technologies need to "allow activities to unfold in a separate sphere", referring to spatial and temporal separation of play from work and productivity. Zhang et al. [27] presented Tagtiles, an interactive educational game for learning about energy and the environment. Their results indicated that for the design of learning systems for children, playful interaction is very important. Designing for play while maintaining a structure (albeit one with a degree of openness [20]) is closely aligned with the design goals of Ghost Hunter.

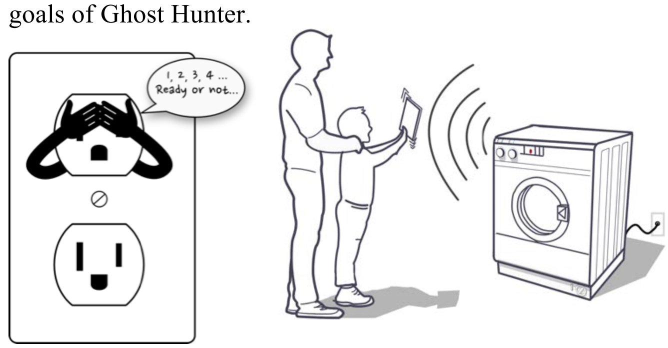

Figure 2. Two Ghost Hunter concept sketches.

DESIGN GOALS AND PROCESS

Our goal in this project is to support informal learning opportunities for parents and children in homes around issues of energy consumption and sustainability. As part of this goal, we hope to encourage productive parental involvement in the activity by tailoring the experience to children's needs and abilities. Finally, we hope to support self-directed and open-ended explorations around four learning objectives.

Learning Objectives

1. To increase awareness of electricity consumption in homes. For example, a child may never have considered that her family's fish tank consumes electricity.
2. To understand that different types of devices and appliances consume different amounts of electricity. For example, a hair dryer uses more energy than a cell phone charger, but only when it's on.
3. To understand that many devices consume electricity even they are off or on standby (so-called vampire power or phantom load).
4. To become familiar with the basic unit of electricity consumption—kilowatt-hours (kWh)—even if families don't entirely understand what the unit means.

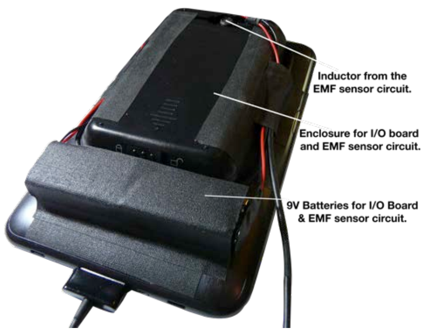

Figure 3. The back of the Ghost Hunter assembly.

Designing from Cultural Forms

In our design process we were guided by the idea of creating learning environments that are responsive to cultural foundations and resources [13, 16, 19, 21]. In particular, we were interested in ways to shape objects and situations so as to evoke existing *cultural forms* [13]. By cultural forms, we refer to social constructions, conventions, and systems of representation that evolve in societies and cultures over relatively long periods of time [24]. Examples include things like counting systems, social conventions, games, tools, monetary currency, and so on. Cultural forms often involve physical artifacts (as in games like dominoes), but they can also consist entirely of patterns of activity (such as games like hide-and-seek).

One valuable property of cultural forms is that they involve predictable patterns of social activity. For example, in a game like hide-and-seek, families have existing patterns of activity that not only enable them to play together but also to help young children learn how to play as well. Think of a toddler playing hide-and-seek with an older sibling or a parent. Parents might do things like ask leading questions ("do you think he could be hiding under something?"), model the physical tasks of hiding and seeking, and provide emotional encouragement at key points during the game. In this project our aim is to evoke specific cultural forms through our designs in an effort to help families bring these kinds of practice-linked resources to bear on the novel activities that our system supports (namely, seeking out sources of electricity consumption).

Thinking about this project from the standpoint of cultural forms helped us to identify several possible design directions. We knew that we wanted to involve parents and children together in exploring the home, and search games seemed like a good fit for the types of activities we were targeting—one in which kids search in odd places (e.g. behind couches and so on) to find hidden things. Given these constraints, we thought that games like hide-and-seek, scavenger hunt, and I-spy-with-my-little-eye would be valuable for supporting parent-child interaction. In our evaluation we describe some of the ways in which parents similarly supported children's learning in energy hunting games.

IMPLEMENTATION

Appliances and devices generate detectable electromagnetic fields (EMF) as they consume electricity. To implement Ghost Hunter we attached a simple EMF detector circuit [5] to a tablet computer (a 7-inch Samsung Galaxy tablet computer running Android 4.0). A small I/O board [15] provides a USB interface between the EMF circuit and a tablet computer (Figure 3). 9V batteries power both the I/O board and the EMF detector. This hardware solution leads to a completely standalone device that is small enough for children to hold and light enough to explore a home with minimal fatigue. This solution has the added benefit of working in any indoor setting because it does not rely on special infrastructure or an augmented environment. This allowed us to increase the ecological validity of our evaluation by testing in participant homes.

An app running on the tablet computer reads EMF values from the I/O board, which are then scaled to a range from 0 to 100. The app presents a menu of common energy consumption appliances shown as a grid of icons (Figure 4, left). When families identify a source of electricity, they can then select one of the icons from the menu. We also provided a generic icon (a light socket) to capture miscellaneous appliances that are not included in our list. After selecting an icon, the app displays information about that particular appliance's energy consumption, both in "on" mode and in "standby" mode (Figure 4, right). Users are then able to add the device to a list energy consumption sources they had found so far. To determine power consumption values for various devices, we used a table of average energy use for a US family in 2006 [26].

We designed the app to give users a combination of visual, auditory, and haptic feedback. The scaled EMF value is shown on a slider (Figure 4, top left); when the value crosses a threshold, the tablet vibrates and beeps at a frequency proportional to the EMF value. This feedback is designed to enable families to *feel* the energy, and the children in our evaluation seemed to enjoy this mix of vibration and sound.

RESEARCH QUESTIONS

In evaluating our prototype, we were interested in three research questions. First, we were interested in the ways in which families would spontaneously use Ghost Hunter in their homes. How would they structure the activity and what roles would various family members play? Second, we were interested in whether or not families would structure their activities around existing cultural forms, specifically search games like hide-and-seek or scavenger hunt? Finally, guided by our four learning objectives, would our design help families learn about energy consumption? Specifically, would families discover unexpected sources of consumption? Would they learn that some things use more electricity than others, and that many devices use electricity even when they are off? And, would they become familiar with the kilowatt-hour as a unit of consumption?

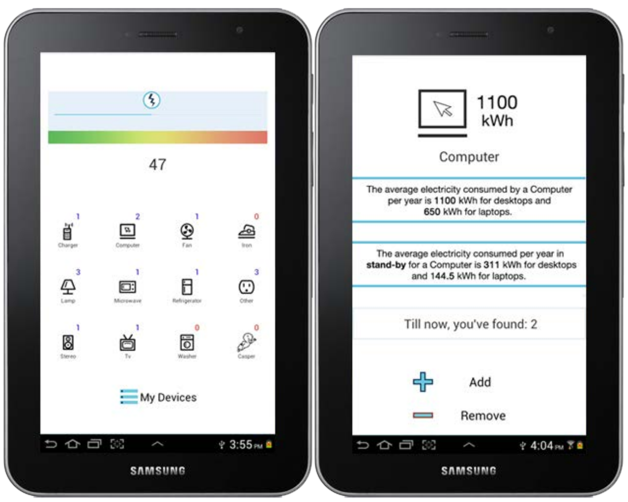

Figure 4. The Ghost Hunter app indicates the strength of an electro-magnetic field (top left) using a combination of visual, auditory, and haptic feedback. The app displays a list of icons (left) showing common devices and appliances. The details screen (right) shows typical consumption levels.

STUDY

Participants

Over a period of one month, we conducted seven evaluation sessions with families in the northern Chicago area. Each session was conducted in the family's home and included at least one parent and one child between five and twelve years of age. The focus of these sessions was to share our design prototypes with families and observe their use of the device. Our participants included a total of 13 adults and 9 children (2 girls and 7 boys). The average age for the children was 6.78 years (SD=2.28). We obtained consent from parents and children to video record their interaction with the device prior to participation. For this study we analyzed all seven family group interactions.

Procedure

We asked families to use the device with minimal instructions. Each family was told that Ghost Hunter was capable of giving visual, auditory, and haptic feedback when it came close to something that uses electricity. They were then encouraged to tap an icon that they thought was responsible for consuming electricity. We asked families to explore their home using the meter and to let us know when they were done. A researcher followed the family around the home with a video recorder to capture the activity. A typical session lasted thirty minutes to one hour.

At the end of the session, we conducted a short follow-up interview in which we asked families to reflect on their experience using the device. We also asked questions about the usability of the device and the ways in which parents might envision using Ghost Hunter with their children. These interviews were audio recorded.

FINDINGS

Patterns of Activity

Our first research question involved understanding how families structured their activities with Ghost Hunter to find sources of energy consumption in their homes. In particular we were interested in the ways in which parents supported their children's interactions. In six out of the seven families that we visited, parents were heavily involved with their children, and at least one parent stayed with the children for the duration of the session. Several types of parental support emerged through our analysis.

Physical Assistance

Parents offered a variety of physical assistance to their children. In some cases, parents took control of Ghost Hunter to reach appliances like a ceiling lamp or a blender on a kitchen counter. In other cases, parents simply picked up their child (Ghost Hunter and all) to let them reach the appliances of interest. Parents also physically enabled children by doing things like rearranging furniture, moving appliances, and opening doors. When parents provided physical support, it was usually at the request of the child, and parents rarely ever grabbed the device away. For example, in the following segment, a 7-year-old boy and his father had just entered the boy's bedroom. Looking up at the ceiling, the boy holds Ghost Hunter up with both hands:

> *Boy: Dad, can you do it for me?*
> *Dad: <taking the Ghost Hunter> Now, how do I do it again?*
> *Boy: Turn off the light; turn it off <runs to the light switch>*
> *Dad: Oh, no. I think we need the light on.*
> *Boy: Yeah*
> *Dad: Want the light on?*
> *Boy: <inaudible> go, go*
> *Dad: Now, can you remind me how to do this again?*
> *Boy: What do you mean?*
> *Dad: What am I supposed to do with it?*

In taking over Ghost Hunter, the father is reluctant to just take the measurement for his son. Instead he quizzes his child about how the device works. This was a common

Figure 5. Kids playing together

occurrence in our evaluation sessions. Parents used similar questions to elicit children's explanations of the activity, creating moments of reflection and reinforcement of concepts.

Conceptual Elaboration

As shown in the previous example, parents tried to help their children understand the activity both through questions and explanations. In this example, a mother and father are exploring the home with their five-year-old daughter. Initially, the father is holding the Ghost Hunter and brings it close to a cell phone plugged in to its charger, causing a beeping noise.

> *Mom and Girl: Whoa-aaa*
> *Mom: What's happening?*
> *Girl: It went all the way up.*
> *Dad: Really far up. But there's no light on my phone. So what do you think it's measuring then?*
> *Girl: It's measuring electricity!*
> *Dad: Maybe, yeah.*
> *[…]*
> *Girl: <holding the Ghost Hunter next to a lamp>*
> *Dad: So, what do you think this would be good for?*
> *Girl: Electricity!*
> *Mom: What would you do… what would it be telling you about electricity, do you think?*
> *Girl: How much it is.*
> *Mom: You think it's how much electricity we're using?*

Throughout this session, both the mother and father asked questions to encourage the girl to expand on her explanations of what Ghost Hunter is measuring. By pointing out that the cell phone didn't have a light, the father was making a reference to an earlier discovery of a lamp that was consuming electricity. Several times in the session, the mother and father repeatedly turned things on and off (like a fan and a lamp) to demonstrate the effect on the EMF reading. At one point after turning a fan on and off several times, the girl speculated that perhaps the wind and electricity were triggering the device.

Parents also helped kids develop a conceptual understanding of the tablet computer app, and particularly the energy icons on the main screen. Parents often asked children what they thought certain icons meant. As an example, one father tried to help his son select the most appropriate icon for a dimmer light switch that he had just discovered: "*Is it a computer? Is it an iron? I don't think it's a refrigerator? <gesturing at the icons>*".

Helping Kids Find Examples of Energy Consumption

The icons on the app also served as a sort of cue card for parents to suggest other sources of electricity consumption that kids might find. Throughout the sessions, parents made suggestions to encourage kids to broaden their search and possibly discover sources of electricity (such as a fish tank or a toy computer) that they might not have considered on their own. Parents didn't necessarily directly instruct their child to try specific appliances, but instead often asked leading questions. For example, "*do you see anything else on there <referring to the computer display> that we've got in the house? Do you recognize any of those pictures?*"

Kids Playing Together

In two of the families, siblings played with Ghost Hunter together (Figure 5). Siblings took on many of the same roles as parents in the sense that they pointed out sources of electricity to test and indicated icons for their brother or sister to press. However, kids issued more direct instructions to one another rather than asking leading questions. We also observed instances of physical assistance. For example, one boy was stretching his body upward with the device to get a reading from a stereo amplifier. As he stretched, his brother helped by pressing the appropriate buttons on the tablet computer for him.

When kids played together, there were often small conflicts over whose turn it was to use the device, and turn taking was probably the most prevalent way in which children shared in the activity, in some cases mediated by the parent.

> *Brother: My turn*
> *Mom: Yeah, you've had a long turn, sweetie*
> *Sister: Oh, I can try this!*
> *Mom: And then it's S's turn, okay?*

Kids Playing Alone

In one family, a ten-year-old boy explored his home by himself. His mother was cooking dinner and the father was watching TV. Despite limited adult interaction, he was still able to find some interesting examples of electricity consumption. For example, his family had an electric trashcan in their home—the lid would open and close automatically using a proximity sensor. This produced a surprisingly strong electrical field that he was able to detect from a couple of feet away. One other interesting thing about this session was that he seemed more interested in exploring energy consumption in his bedroom rather than shared living spaces, which was more common in the other families.

Evoking Cultural Forms

For our second research question, we were interested in whether or not we were able to evoke existing cultural forms through our design, particularly search games like hide-and-seek and scavenger hunt. On a superficial level, our observations indicated that kids and families were searching in odd unusual places for hidden things, reminiscent of a game of hide and seek. We also saw the use the app icons as a sort of checklist for framing the bounds of the activity. This seemed similar to a scavenger hunt. Perhaps more telling, however, were the small details of family interaction such as parents asking leading questions about where kids might find different sources of electricity consumption.

Beyond observing similarities between one type of activity and another, we also use post-interviews with families to try to elicit spontaneous connections from participants. In our sessions we were careful not to mention any specific games like hide-and-seek. One of our interview questions asked participants if the activity reminded them of any games, one boy replied:

> *Boy: hide-and-go-electrical*
> *Researcher: ha ha. okay.*
> *Mom: Like hide-and-go-seek?*

Other families had similar reactions:

> *Dad: Was it like a treasure hunt?*
> *Boy: Kind of like an electricity hunt.*

While families commonly referred to these types of games and activities, there were some exceptions. In one instance, a father mentioned that it felt like using a metal detector or a Geiger counter, while his daughter said that the activity felt like "science game". In another instance, a parent quizzed the child and helped him figure out the source of energy consumption by a process of elimination similar to the game 20-questions. In all, family activities patterns resembled search games for our target cultural forms. However, it is still unclear to what extent our design prompted these activities rather than families spontaneously adapted existing practices to suit the new task.

Learning about Energy Consumption

For our last research question we were interested in whether or not families learned about energy consumption by using our system. Recall that we are interested in four target learning objectives.

1. Unexpected sources of consumption

Our first learning objective was to increase family awareness of household energy consumption. This outcome was likely achieved for the children in our study (usually with parental guidance). In most cases with parental guidance, children identified things like phone chargers, speakers, ceiling fans, and electric trashcans. It wasn't so much that children were surprised that these things used electricity as it was that the activity seemed to increase their awareness of just how many different things in a home consume electricity.

2. Standby power consumption

Many household devices are always on (and always using electricity), but have distinct standby and active modes. For example, a microwave is always on displaying a clock, but is active when cooking. Microwaves were a phantom power draw that families found surprising despite the constant clock display. Three families found dishwashers' phantom draw to be a surprise since there was no constant display. Parents also used the Ghost Hunter to illustrate the difference between devices on standby versus active mode. Some families started the microwave to see if it would activate Ghost Hunter from farther away. Other devices, such as stereo amplifiers, elicited a similar response.

3. Familiarization with units of consumption.

We asked parents if they thought they could use the energy measurements displayed in the system to teach their kids about units of energy consumption, such as watts and kilowatt-hours. Three of the parents said that the system could serve this purpose using the information displayed on the *add device* screen. The other four families said the units of measurement would be difficult for the children to understand. However, using values displayed for multiple devices would give children a basis to compare energy consumption on a scale. Some families suggested that having a dollar amount would help to relate energy consumption values to children by emphasizing its influence on expenses. Parents were also interested in seeing values over different periods time (e.g. weekly, monthly, yearly). It is important to note that during the activity, children were more focused on finding devices and adding them to the list rather than reading the page of information. However, when parents were assisting they often highlighted these values, though this rarely resulted in discussions.

4. *Learning about differences in consumption*

Our final learning objective was for families to understand that different devices consume different amounts of electricity. Ghost Hunter only seemed to be effective for this outcome in more extreme cases. For example, when a clothes drying machine is on, it produces a surprisingly strong EMF reading that activates Ghost Hunter from a few feet away, whereas most other appliances only activate the system from a range of a few inches. However, as mentioned above, families were mostly focused on exploring their homes rather than comparing different devices that they had already discovered.

DISCUSSION

Even though kids are active consumers of electricity and other forms of energy in homes, sustainable interaction design research has tended to focus on adults. While there is certainly value in targeting adults (who arguably consume the greatest proportion of energy and pay the bills), this focus might miss out on a valuable opportunities to engage and empower young people to help move toward a more sustainable future. Ballantyne et al. [1] have made the case that involving kids in environmental education is not unidirectional, with parents simply imparting knowledge to their children. On the contrary, children might be instrumental in shaping family attitudes with respect to the environment [1]. In this paper, we present a design that takes a step in the direction of involving children as active participants in understanding energy consumption. Our intention with Ghost Hunter was, on the one hand, to take advantage of the "games" that many families seem to play spontaneously when they first install eco-feedback displays [6]. These activities coalesce around challenges like, "let's try to get our energy consumption down to zero." And they seem to echo familiar search games like hide-and-seek. By the same token, we sought to use our design to evoke the underlying cultural forms that these games represented, and, by extension, to cue potentially valuable practices. Ideally these practices involve resources that can be brought to bear on the task of understanding energy consumption in its various guises, and in thinking about the ramifications of such consumption.

Parental activities like offering physical assistance, conceptual elaboration of the task, and suggesting unexpected sources of energy consumption seemed valuable in helping kids learn through the activity. In terms of our target learning objectives, we were more successful in some areas than others. Ghost Hunter seemed good at helping families identify standby energy vampires and in realizing that some devices consume more electricity than others based on the strength of the EMF reading. However, we were less successful in getting families to pay attention to numeric values associated with various devices, and families never once mentioned the word "kilowatt hour" during the search sessions. This could be related to the kinds of cultural forms that we were attempting to evoke. Search games involve finding hidden things but not necessarily comparing the relative values of those things. It is possible that other cultural forms (such as children's card games) would be better for these sorts of outcomes.

Although communication about broader issues of sustainability was limited, there were subtle interactions between parents that went beyond just finding devices that draw electricity. For example, one family had a geothermal heating system in their home. When the kids went to the basement to explore the area with the Ghost Hunter, the father quizzed the kids about the system and then tried to explain how it worked. A few families talked about consumption in numeric terms but without reference to the unit, kWh). We believe that the Ghost Hunter was the catalyst for these conversations about household infrastructure.

We also noticed a distinct difference in the strategy involved in finding hidden sources of energy consumption based on the degree of adult supervision during the activity. Kids playing together were more inclined to go explore the entire home to try and find all sorts of devices, even those that were not on the list presented on the Ghost Hunter interface. Parents, on the other hand, seemed to use the interface elements as a checklist to guide their children towards the devices and appliances listed on the interface.

While our study in its current form cannot measure long-term behavior change, we believe that the device lends itself well for use more than once. Firstly, home electricity consumption changes based on factors like seasons, newly acquired devices etc. And, secondly, kids did not want to give up this device and often turned this activity into a cooperative or competitive endeavor; this gives us hope that kids might share this with their friends.

LIMITATIONS AND FUTURE WORK

As a concept exploration, we believe that Ghost Hunter was a success. However, more work would need to be done to bring this sort of in home learning experience to a wider audience. With the current design of the Ghost Hunter, there are a few cases where it is difficult to isolate the source of an electromagnetic field. For example, if a coffee maker is on a kitchen counter in front of a microwave, pointing at the coffee maker can trigger the device, but it might not be immediately obvious which device was responsible. There are also some situations in which ambient electro-magnetic fields can interfere with the detector circuit. These occasional false alarms could reinforce incorrect understandings. For example, one child got a small reading from a heating vent. While our design had an icon of 'Casper' (the friendly ghost) precisely for instances where the Ghost Hunter registered a false reading, this usually required adult intervention to clarify its purpose.

Our software app, while simple, could also be improved. For example, we witnessed that for one girl, the goal of the activity seemed to shift, and she seemed to by trying to get 100 out of 100 on the EMF scale on the display. In a future version, we might remove the numeric value because it only corresponds to the strength of the EMF reading rather than actual current draw. It might also be interesting to combine Ghost Hunter with off-the-shelf whole-home electricity meters to provide multiple ways for families to understand consumption.

CONCLUSION

In this paper we presented the design and evaluation of Ghost Hunter, a device designed to engage parents and children in informal learning activities in which they seek out "hidden" sources of electricity consumption in their homes. We believe that there are two complementary contributions of this work. The first is to investigate ways to involve entire families in learning about energy consumption. Our design concept begins to explore this space; we tried to assess what worked and what didn't for this particular approach. The second contribution is to explore the use of cultural forms as a foundation for interaction design to promote sustainability. We propose this as having less to do with improving the usability of the interface, and more to do with cueing productive social activities around the interface to improve the quality of the overall experience. There is evidence that we were able to evoke specific types of cultural forms (e.g. hide-and-seek) with a minimal design. Our evaluation with seven families revealed a variety of ways in which parents structured and supported their children's interactions and discovered unexpected sources of energy consumption.

ACKNOWLEDGMENTS

Reed Stevens, Laurel Schrementi, Pei-Yi Kuo, Michael Greenberg, Zeina Leong, and Andreas Wadum contributed to this work. This research was supported by the Institute for Sustainability and Energy at Northwestern (ISEN) and the National Science Foundation (grant IIS-1123574). Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the Foundation.

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