An Energy Lifestyles Program for Tweens: A Pilot Study

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ABSTRACT

Prior work has demonstrated that energy education programs designed for young children can influence the adoption of energy efficiency measures in the home. Here, we introduce the Know Your Energy Numbers (KYEN) program, an energy education program designed to teach an older audience of pre-teens, or tweens, about: (i) their energy consumption lifestyles, (ii) available residential energy tools, and (iii) methods to extract insights from their energy data. We also describe results from two pilots with 18 tweens from Girl Scout and Boy Scout troops living in

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Energy; Energy education; Tweens; Families; Behavior change; Smart meter data; Sustainability; Sustainable HCI

Figure 1: A Rainforest Automation™ EMU-2 device illustrates one type of energy display that families could use to assist them with understanding energy use and pricing at home.

Figure 2: A programmable, Wi-Fi enabled Wemo™ smart plug like those used by students in our energy program during post-session, at-home activities.

Northern California. We report on how participants and their families reacted to our energy-based curricula, the benefits and challenges they perceived about using energy tools, and their preferences regarding the display of home energy data. We conclude with a brief discussion of the outcomes and limitations of this work before describing next steps for the program.

1 INTRODUCTION

As part of the growing Advanced Metering Infrastructure (AMI) in the US, smart meters that measure electricity usage in real-time are increasingly being installed in residential homes nationwide (*e.g.,* up from 24% in 2014 to 50% in 2017) [1-2]. As a result, high-resolution data about electrical consumption is becoming increasingly available through online web portals and mobile applications which are enabling new interactions between utility companies and customers [1-2]. Complementing this increased access to data are a growing number of Home Automation Network (HAN) devices (*e.g.,* smart plugs, in-home energy displays) like those shown in Figures 1 & 2. These technologies are designed to allow consumers to meaningfully engage with and make decisions about the way they use energy to achieve goals like lowering utility bills, reducing environmental impact, and—critically—responding to changes in energy pricing and availability. However, a problem for consumers is that these tools and services are often built for the energy and technology savvy who have the time and resources to utilize them effectively [3-4]. As a result, the need to adapt to dynamic pricing and/or utilize new technologies can put additional strain on large households, particularly those with school-aged children who (i) make up 45% of US households as of 2017 [5], (ii) have constrained energy usage patterns [6], and (iii) may not be well-versed on energy issues or available tools to manage them [7].

One way of addressing these issues is through energy education programs. Recent work by Boudet *et al.* [6] demonstrates that programs designed for young children can help educate families about energy issues and influence the adoption of energy efficiency measures. However, there are considerable limitations on young children in terms of household agency (*e.g.,* young children are often responsible for turning off lights when they exit a room but are usually not responsible for more energy intensive activities like laundry) and, thus, their ability to advocate for change. Expanding upon this work, we introduce the Know Your Energy Numbers (KYEN) program, an energy education program being iteratively designed to teach an older audience of pre-teens, or tweens, who are more engaged with their home's energy services about: (i) their energy consumption lifestyles, (ii) available residential energy tools, and (iii) methods to extract insights from their energy data (*e.g.,* through the analysis of load shapes [8]). As formative work, our research questions are exploratory and include: *How do tweens respond to energy curriculum and activities? What challenges and benefits do they perceive about using energy tools and devices? And, what are their preferences regarding the display of home energy data?*

Figure 3: (top to bottom) An energy lecturette, an example of using design thinking techniques to ideate about energy issues, and one of our in-class energy measurement and calculation exercises with household devices.

2 PROGRAM OVERVIEW

Based on prior work [6], the Know Your Energy Numbers (KYEN) program is a prototype energy education program being interactively designed by faculty, researchers, and students at Oregon State University and Stanford University. The program's goal is to educate young people about energy issues that may impact them and teach them about what they can do in response to help save money and improve residential energy efficiency. Focusing on tweens, the program is a five-session workshop series designed to provide students with the knowledge, skills, and personal self-efficacy to create sustainable changes in their personal energy consumption lifestyles *and* influence other family members. Each 90-minute session in the series builds on the previous through: brief energy concept lecturettes, reviews of household energy data, interactive team-based activities, and at-home exercises. Throughout the program students are introduced to: (i) key energy-related terms and concepts to use during discussions, (ii) energy tools to help them measure and track their family's energy consumption, (iii) common ways to save energy at home, and (iv) social science theories on energy-related behavior change that recognize energy is used to fulfill needs and accomplish social practices such as cooking, cleaning, and relaxing [9].

2.1 Session Format

Here, we describe the KYEN program session components (Figure 3) in more detail:

- Sessions begin with lecturettes aimed at teaching students key energy concepts (*e.g.,* production, consumption) and terms (*e.g.,* smart grid, load shape, peak load, TOU pricing). Lessons are reviewed at the start of the next session through gamified, vocabulary quizzes (via the learning platform, Kahoot! ™, https://kahoot.com).
- After discussing the lecturettes, students get a chance to engage with different energy management technologies (*e.g.,* programmable smart plug - Figure 2) and sources of data about their family's energy consumption (*e.g.,* utility provider's web-site). Additionally, Researchers provide personalized visualizations of each student's home energy data, which the group then discusses, that complement each session's learning objectives (Figure 4).
- Design thinking techniques and methods (*e.g.,* sticky noting, Figure 3-middle) are then introduced to help students brainstorm about how to enact behavior changes at home (*e.g.,* identifying/preventing vampire loads, washing clothing using cold water or when energy is cheaper) through small, team-based activities.
- Each session finishes with (i) group presentations (*i.e.,* typically short skits modeling conversations about energy issues with family members) that are recorded and reviewed during future sessions and (ii) a discussion of the at-home activities students are to complete before the next session (*e.g.,* set up and explore your home with provided smart plug devices, enact a personal behavior change).

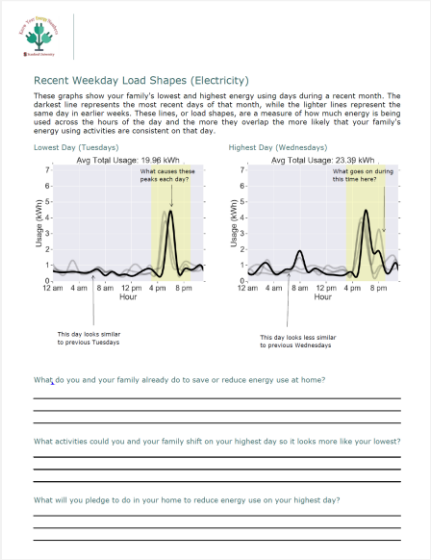

Figure 4: Using hourly smart meter energy data provided by parents, the research team designed and distributed a series of personalized energy visualizations that displayed daily, weekly, and yearly summaries of energy consumption. These handouts were designed to be engaging and included fill-in-the-blank type worksheets as well as personalized notes about household energy use.

3 PILOT EVALUATION

To begin investigating our research questions and the efficacy of our preliminary program curriculum, we iteratively conducted two five-session workshops with 18 tweens from Girl Scout and Boy Scout troops in Northern California. Each troop consisted of 9 scouts. The region of California was selected due to the relatively high availability of residential smart meter data.

3.1 Method

Scouts met in a local residence or community building for workshop sessions spread across five consecutive Saturdays (as part of their regular troop meetings). Before enrolling troops in the KYEN program both parents and scouts provided informed consent and assent, respectively. Two members of the research team led each session, took observational notes, and documented activities (via photographs) with additional help from university students and senior scouts from older troops. To reinforce lessons, scouts performed activities at home, set conservation goals, and discussed progress with these across session. During the program, parents and scouts received weekly newsletters (via email) with program updates and reminders.

On the final Saturday, scouts and their families visited an energy lab on the Stanford University campus for a tour (Figure 6). After the tour, scouts attended the final session and then completed a brief survey about their experience in the program, discussed ways in which the program could be improved, and received certificates of completion. Additionally, these visits provided researchers with opportunities to informally discuss with parents the impacts of the program at home. Responses to the surveys and session notes were organized into several themes.

As the two pilots were non-concurrent, the customized visualizations were only introduced in the second series of workshops with the Girl Scout troop. This was based on earlier feedback from scouts that suggested providing views of their family's data that better complemented the learning objectives of certain sessions, but that may not be easily accessible on the mobile interfaces that were accessible to them. To create these visualizations, parents downloaded and shared their household's smart metered energy data for the prior calendar year with the research team.

3.2 Results

We report on scouts reactions to the KYEN energy curriculum, the benefits and challenges they perceived about using energy tools, their preferences regarding the display of home energy data, and their thoughts on energy conservation at home. We also briefly discuss program outcomes and the scouts suggestions for improvement.

Reactions to energy curriculum. Comments and discussions with scouts about the lecturettes and activities were positive, though some indicated that certain content felt repetitive (*e.g.,* ways in which they could save energy at home could go deeper and broader). Surveys indicated that

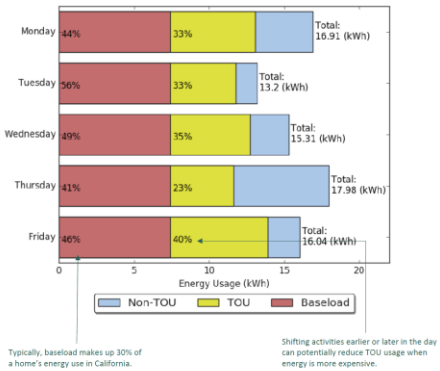

Figure 5: As they learned more about how energy data can be dis-aggregated (*e.g.,* by usage type: base-load from always on devices versus other uses) via our supplementary visualizations, scouts become more interested in exploring the granularity of energy data.

Figure 6: The KYEN program's last session features a tour of an energy lab where students learn about potential, future energy production, distribution, and demand response methods.

reviewing content through Kahoot was viewed by all scouts as being at least somewhat effective with 40% rating the activity as extremely effective. Scouts reported learning about energy consumption at home and specific energy concepts (*e.g.,* the difference between watts and kilowatt-hours). Researchers also observed that scouts were enthusiastic, became more accustomed to using energy terminology, and appeared more confident in group discussions.

Benefits and challenges of using in-home energy devices. Scouts found using energy meters (*i.e.,* plug load devices which display the amount of power a device consumes) in the classroom to be an easy and engaging activity that allowed them to perform basic calculations about how much energy everyday devices use. Scouts suggested including more of these hands-on activities and, perhaps, more advanced activities in future programs. Researchers observed that their experiences in the classroom made scouts excited to try more advanced HAN devices at home. However, setting up smart plugs outside of the sessions was largely unsuccessful and frustrating. Often this was due to technical issues (*e.g.,* Wi-Fi signal strength not being strong enough, faulty sensors not registering data). However, those who got their devices set up were more positive, reporting interest in the additional data that was provided. As a result of these issues, most scouts were unable to use or explore the more advanced features of these devices (*e.g.,* automation, data analysis).

Home energy data viewing preferences. Overall, scouts viewed the visualization components of the program positively, with 78% of participants reporting that reviewing visualizations of their family's energy data was an extremely effective exercise. Scouts expressed interest in understanding temporal trends in their annual and hourly data, such as seasonal patterns (*e.g.* higher electricity use for cooling the home in the summer months) and the effects of household activities (*e.g.* low periods of use during certain times of the day or week). When reviewing load shapes, for example, they preferred to see multiple days simultaneously to see similarities and difference across days (as in Figure 4) rather than viewing a single day's data. A technical challenge scouts encountered when interpreting household energy data was due to substantial household heterogeneity in terms of electricity consumption and production patterns (i.e., several participating households owned solar panels, electric vehicles, pools, and/or hot tubs that were difficult to identify). However, scouts were often able, with mixed-confidence, to hypothesize reasons for the observations they made about their data. Scouts also indicated that they were interested in more information about individual household devices in future visualizations (Figure 5). For homes with rooftop solar, scouts indicated interest in tracking consumption and production.

Ideas around conservation. Throughout the program we observed that most scouts gravitated towards several common energy saving solutions (particularly regarding solutions to dynamic, TOU pricing models). Scouts most often suggested minor shifts in activities (*e.g.,* doing homework

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earlier in the day to take advantage of natural light) or family-wide behavior changes (*e.g.,* taking shorter showers, using a plug bar to charge devices and remembering to turn it off when not in use). Scouts also suggested curtailing or not engaging in certain activities but admitted it would be challenging to give up their phones, computers, and other electronic devices outside of already established household rules. Survey responses indicated that scouts felt the program should include a broader range of energy saving activities that they could apply/try at home.

Discussion of outcomes. Overall, scouts were enthusiastic about the KYENs program, with most reporting the activities and components to be at least somewhat effective. All scouts reported an intention to continue engaging in energy saving activities, but most were unsure about actively sharing this information with others in the future. During informal conversations, parents were enthusiastic about the program and reported observing their child's increased awareness of energy use at home. A few parents even observed that their child seemed more informed on energy issues than they were themselves. Based on conversations with scouts at the end of the program, it was s suggested that we add more hands-on activities to the curriculum (*i.e.,* using smart devices and mobile apps) provided, of course, that setup challenges can be resolved/avoided. Scouts even suggested including more sessions that would allow them to engage in more substantial prototyping activities (*e.g.,* building an app/device that could help them with energy management).

4 CONCLUSIONS

In this work, we presented the Know Your Energy Numbers (KYEN) program, an energy education program being iteratively designed to help tweens and their families understand their energy lifestyles and data. Ultimately, our participants were (i) positive about the energy curricula, (ii) preferred energy visualizations that allowed them to view their home's energy data at different scales and desired more advanced views (*e.g.,* device-level disaggregation), and (iii) were engaged by hands-on activities with energy tools. However, it should be noted that further testing with a larger, more diverse population will be necessary to see if the KYEN program will have the desired impact. Next steps for the program's development include: (i) refining our energy curriculum, (ii) exploring recent advances in methods to collect behavioral data about energy use, and (iii) co-designing a mobile application and sensor kit to support both classroom and at-home activities.

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