Designing Your Energy Lifestyle: Data Thinking – Data Visualization

A project of the Smart and Connected Kids for Sustainable Energy Communities Initiative

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Background

Increasingly educators are acknowledging the importance of engaging youth in data science and data thinking.[i] This includes conveying information on what is data, examination of types of data such as time series data, how to visualize data, and use of tools for data analysis and visualization – as a way to prepare youth for success in an increasingly data-driven world.[ii] At the same time, research has demonstrated that youth have agency within their families and can lead and support family efforts to reduce energy and advance environmental actions.[iii] Combining these concepts, we introduce the Designing Your Energy Lifestyle: Data Thinking – Data Visualization[iv] workshop series, a Science, Technology, Engineering, Arts and Humanities, and Math (STEAM) focused,[v] behavior change theory driven, research-based program for middle and early high school aged youth[vi] that aims to increase energy data literacy while building knowledge and promoting household energy savings.[vii] Through a series of three, three-hour workshops, middle and high school students learned about energy data and data visualization, practiced creating personal household visualizations, created a story around those visualizations, and presented a portfolio of these visualizations in the context of a household energy conservation management story (Figure 1 – Participants examining each other's visualizations).

Program Development

Key outcome educational and behavioral objectives for participants included:

Figure 1: Participants sharing their energy visualizations created in Tableau

- Learn the basics of data collection, cleaning, and labeling,
- Learn and become adept with the use of *Tableau*[viii] as a data visualization tool,
- Understand key energy concepts, time of use pricing, daily load shape, peak and baseload consumption
- Understand and can apply behavior change strategies such as shifting energy consumption practices, increasing non-energy consuming activities such as taking a walk with family members or reading, and increasing energy efficiency such as using full loads of dishes, cold water washing, and efficient use of the refrigerator.
- Participate in design thinking methods of brainstorming regarding why save energy, creating home energy saving prototypes, and evaluating, iterating, and reporting team ideas,
- Collect and analyze household energy consuming activities via interviews, observation, and diaries,

- Combine self-generated reports about energy consuming activities in the home with actual energy data to reveal insights regarding household energy use activities such as their energy intensity, time of day, room location, and social practice goals such as nourishment, cleaning, entertainment/work, and socialization,
- Create as a team an “explainity” video[ix] for end of session viewing
- Present a portfolio of work to a jury of data scientists, engineers, graduate students, educators, and architect students and receive feedback

Figure 3: Dinner Table Deck of Cards

The workshop series draws on key energy concepts that emerged from research led by Associate Professor Ram Rajagopal using smart-metered hourly household energy usage data. Concepts include energy load shape, kWh use over a 24 hour period; peak load, kWh consumption and hour of highest use in a day; and base load, the lowest use hour multiplied by 24 hours is the amount of idle and ‘vampire” energy in a day and data and statistical features derived from these core notions. Each of the three-hour workshops focuses on one core energy concept and its characteristics. Load shape features for example include stability of load shape over time, name of load shape (e.g. dual peaking, afternoon, average daily electricity (kWh) use, and proportion of total consumption that is peak use and baseload consumption.[x] Further, the curriculum incorporates key behavioral science concepts of personalization, monitoring, feedback and goal setting. Personalization includes working with one’s own household electricity data, journaling about the energy consumption of participants’ families and building energy reduction plans for one’s family. Skill acquisition, behavioral modeling and behavioral rehearsal are other key theory-based concepts drawn from social cognitive theory that are integrated throughout; such as making public behavioral commitments to reduce energy and building family energy reduction plans. Theories of parent-child communication underpin other activities such as interviewing family members about energy consumption and using communication tools such as the “Dinner Table Deck of Cards” (Figure 3); Finally, workshops are rooted in key design thinking concepts and methods such as ideation, prototyping, iteration, and problem framing.[xi]

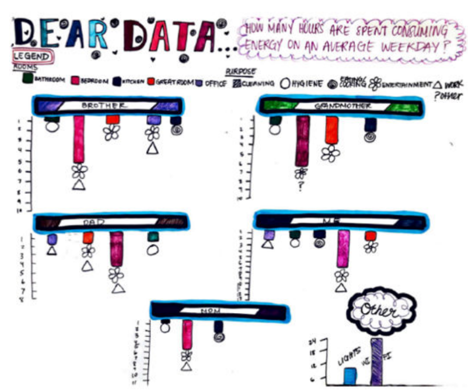


Figure 2: A participant's hand drawn "Dear Diary" energy visualization

Two key data visualization tools were used – the computational data visualization tool Tableau© and informational visualization strategies showcased in the text and website “Dear Data” and Dear Data Two projects[xii] (See Figure 3 for sample participants’ Dear Data energy visualization).

In the workshops, participants learned how to upload their PG&E data into Tableau, clean the data, create visualizations and interpret those visualizations by asking questions of the data and reporting household energy consumption insights. By the end of the program, participants used Tableau and to produce their own personalized visualizations of their household's energy use. In addition to "inventing" their own data visualizations in Tableau, they also created a portfolio of visualizations representing three energy time-series data concepts featured in Professor Rajagopal's work: load shape, peak load, and baseload. In the final session, participants presented those visualizations to a jury of Stanford and outside experts and received tailored feedback on their portfolio of visualizations (See Figure 4 for sample of student-generated visualizations).

Figure 4: Example of student visualizations from their portfolio presentation. Top left (1), estimated daily load shape prior to data visualization; bottom left (2), actual daily load shape with annotated activities; right (3), load shapes displayed across 1 week.

Workshop materials were often created by high school summer interns and included items below and are available for viewing here: https://stanford.box.com/s/58j5a05tlard1uy7v10lpopxeewkr6ta

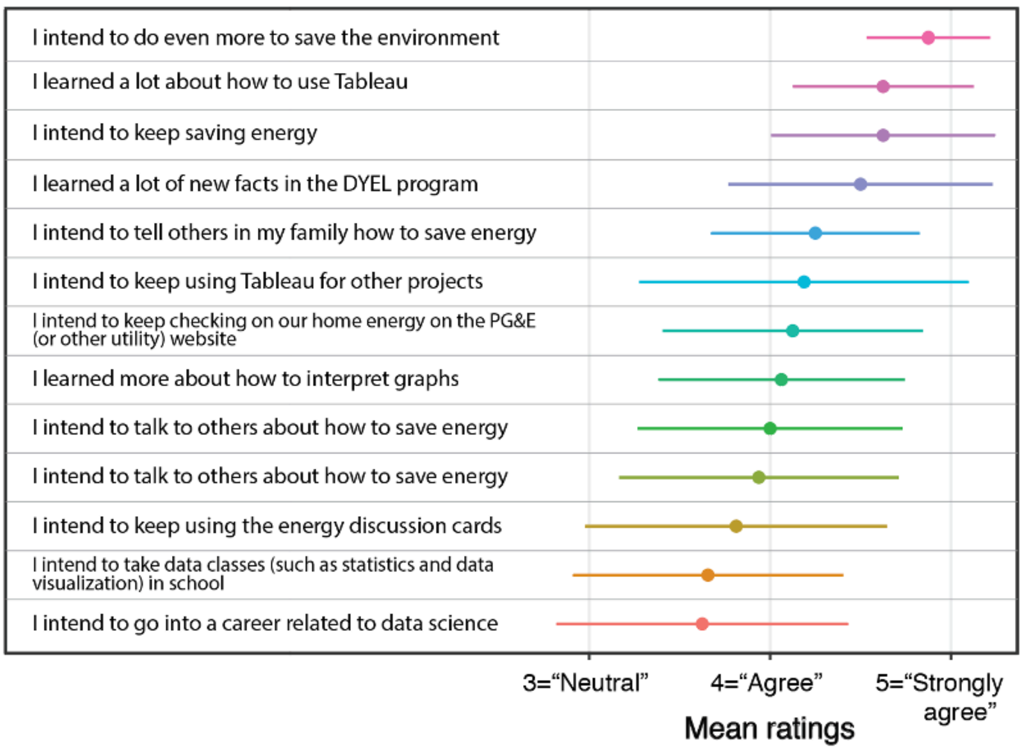
- Tailored videos on how to use Tableau for energy data visualization
- Behavioral change tools including drawn animations, stop motion animations, sample portfolio videos, dinner table deck of conversations card game, a rate your family's readiness to change scorecard, video on "Tiny Habits" theory[xiii], a motivational interviewing theory-based video on how to have a save energy conversation,
- A family energy activity journal,
- A Kill-a-Watt meter plug load activity,
- Drawn visualizations activities,
- Brainstorming about energy and energy conservation,
- Prototyping of family energy reduction plans,

Workshops were led by Stanford Staff, postdoctoral fellows, undergraduates and high school interns. To date two educational pilot programs have been conducted with a total of 30 middle and early high school youth in Fremont, CA in the summer of 2019. At the end of the last session of the August 2019 workshop series, participants were given a survey to evaluate their experiences with the program. In this survey, participants were asked to rate their behavioral intentions after participating in the program and the effectiveness of various program components.

Participant Outcomes

See Table 1 for mean ratings of intentions and perceived learnings. Statements receiving the highest ratings were intentions to do more to save the environment and energy, and new knowledge about energy and use of Tableau. Some of next highest rated statements indicated a willingness to continue using Tableau and communicate to family members about how to save energy and keep using the PG&E website. The components of the workshops the participants found most effective were the core parts of the program (the instructors, juried presentation, use of Tableau, and lecturettes). Activities assigned as homework were rated lower; qualitative feedback from participants indicated that some participants had a negative attitude towards homework more generally.

Table 1. Mean ratings for behavioral intentions and perceived learnings. Responses on a Likert-type scale with 0 = "Strongly disagree", 1 = "Disagree", 3 = "Neutral", 4 = "Agree", and 5 = "Strongly agree". Points are means and lines represent one standard deviation.



Future Programs

The current funding for the pilot educational programs has ended and we are seeking funding partners to scale these STEAM – Energy programs that advance young people's understanding of and motivation to help save the environment and conserve energy. Not only was the workshop series a success in engaging tween-aged youth and their families, over the two workshops series six high school interns, two Stanford students (SUPER and MUIR fellows), post-doctoral fellows, as well as volunteer Stanford graduate students, staff and participant family parents served as jury members. The student interns were essential for developing curricula materials and created innovative presentation materials such as drawn animations, stop motions videos, artistic created data visualizations, multiple Tableau and energy data videos, and multiple explainity videos as well as teaching aspects of the curriculum and serving as Tableau consulting "experts". We also worked with multiple partners: Northern California Girl Scout Council, Boy Scouts of America; Tableau, and Big Trunk Data.

Previously we have scaled energy-based programs with young children via Girl Scouts (http://www.glee.stanford.edu) where we disseminated a five-session energy behavior change program to Girl Scout Troops in 33 states and worked with most of the 121 Girl Scout Councils in the US. Critical aspects of that scaling endeavor were well designed and packaged free print materials, an online training course with many brief "teaching practice" videos, a resource rich and multi-audience focused website, and staff to manage the scaling effort as well as consult with users. We seek funding and resource partners to "package" the workshop leader presentations, materials, and activities that would allow wide spread dissemination to schools, after school youth programs, informal learning spaces such as libraries and science museums. In particular, we aim to disseminate the program to communities and with youth groups that are often underserved regarding STEAM, energy and environmental engagement.

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[xiii] B. J. Fogg Ph.D. Behavioral Design Lab, Stanford University https://www.behaviormodel.org/

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