Energy Saving Emily

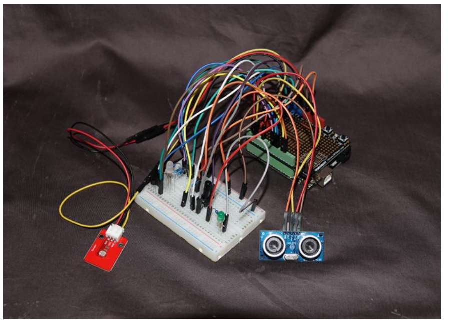
Emily is an energy-saving product that monitors the users' energy consumption and alerting them of any misuse.

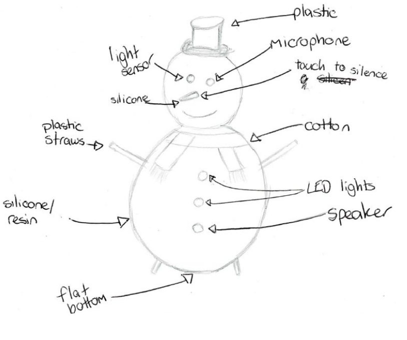
Emily is designed to make households conscious of their energy consumption. The device can detect multiple misuses of energy usage such as if the air-conditioning/heater is on and if it is the same temperature outside or if the lights are left on when no one is in the room. Emily communicates with the user through light and sound and allows the user to communicate to it using touch. Emily is aimed to assist Australians to improve on their energy consumption and create a more energy efficient home. In recent years, Australia was named the world's worst-performing major developed country in energy consumption which leaves a huge opportunity for future development within energy efficiency [1].

Through research, it is evident that giving users feedback through digital technologies can be an effective way to disrupt and change their habits. The feedback characteristics that should be included are feedback signs, comparison, tailoring, modality, frequency, timing and duration [2]. By disrupting their habits it allows users to become consciously aware of their habitual behaviour. For smart energy technologies to be effective, it was stated that users should be able to access the device in their everyday life and hold attractive and interesting qualities whilst being shared by all members of the households [3].

This branches off from the team's concept as it focuses on households and families who are familiar with technology and are likely to incorporate it into their house and interact with it frequently. This creates a different focus as to how the users perceive Emily and interact with her. As many users are aware of what is "good' and "bad" energy use, the focus is on constant reminders and altering their habits.

Emily can be viewed in action here:
(https://youtu.be/PqGLW4STyT0)





[1]F. Castro-Alvarez, S. Vaidyanathan, H. Bastian and J. King, *The 2018 International Energy Efficiency Scorecard*. American Council for an Energy-Efficient Economy, 2018.
[2]S. Hermsen, J. Frost, R. Renes and P. Kerkhof, "Using feedback through digital technology to disrupt and change habitual behavior: A critical review of current literature", *Computers in Human Behavior*, vol. 57, pp. 61-74, 2016. Available: 10.1016/j.chb.2015.12.023 [Accessed 26 April 2020].
[3]C. Kobus, "A switch by design: User-centred design of smart energy technologies to change habits of using energy at home", 2016. Available: https://doi.org/10.4233/uuid:a2bd0f3f-ce85-464e-a8bc-a7c0b505d784 [Accessed 26 April 2020].

Design Process

After carefully considering the work the team completed as well as my focus, I decided to conduct some research to gain further insight into my concept. I decided to research the effectiveness of feedback within technology to change habits, the use of smart energy technologies and how users develop trust within technology. Within the research conducted, I discovered that:

- Feedback characteristics within digital technologies should include feedback sign, comparison, tailoring, modality, frequency, timing and duration. [2]
- Lights, signals, buzzes, beeps and push messages can help break habits and offers the user the opportunity for "reflection in action". [2]
- The disruption and change of habitual behaviour are effective by providing the user with high initial engagement with the product as well as having a target goal, strong motivation or high perceived self-efficacy. [2]
- High-frequency feedback over a long period is an effective way to disrupt habitual behaviour. [2]
- Users need to be provided with real-time feedback, so they relate their habitual feedback to their conscious awareness. [2, 3]
- The product needs to be incorporated into the user's everyday life whilst also being attractive and interesting and accessible to all household members. [3]
- To best gain the user's trust, the product should have the following factors: reliability, etiquette, usability, social presence and visual design. [4]

With these discoveries in mind, I altered my concept to consider these factors. Negative Nancies had researched our problem space and took those findings into account when first creating our solution. The research conducted became specific to my individual focus and assisted me to develop my product in a way that will benefit the user. This is intended to improve the user's experience and outcomes. These alterations include:

- Constant feedback compared to feedback on action – continual lights representing good and bad behaviour rather than only negative responses when habits are broken.
- A larger focus on the aesthetics of the product – ensuring Emily is appealing to user's and the responses are understood visually.
- Higher engagement between the user and the product – touch to dismiss when a habit has been broken.

After altering my concept, I broke down each feature of Emily and how the user will interact with her. This helped to identify my intended interactions and relative responses. These features were designed to satisfy the recommendations discovered in my research. Being able to identify the materials to be used, the features of the device and the habits that are monitored along with their responses. This created a clear idea of how to implement my technology into the Arduino and what materials I would need to build my product. I was able to gather those materials and then commence building Emily.

[2]S. Hermsen, J. Frost, R. Renes and P. Kerkhof, "Using feedback through digital technology to disrupt and change habitual behavior: A critical review of current literature", *Computers in Human Behavior*, vol. 57, pp. 61-74, 2016. Available: 10.1016/j.chb.2015.12.023 [Accessed 26 April 2020].

[3]C. Kobus, "A switch by design: User-centred design of smart energy technologies to change habits of using energy at home", 2016. Available: https://doi.org/10.4233/uuid:a2bd0f3f-ce85-464e-a8bc-a7c0b505d784 [Accessed 26 April 2020].

[4]J. Xu, K. Le, A. Deitermann and E. Montague, "How different types of users develop trust in technology: A qualitative analysis of the antecedents of active and passive user trust in a shared technology", *Applied Ergonomics*, vol. 45, no. 6, pp. 1495-1503, 2014. Available: http://europepmc.org/backend/ptpmcrender.fcgi?accid=PMC4237160&blobtype=pdf. [Accessed 26 April 2020].

Design Process

I already had an overall idea of what I hoped my product would look like. I wished to incorporate a representation of weather with a design that users could form an emotional connection to. This led my decision to design a snowman, with inspiration coming from Olaf from the movie Frozen. I sketched my proposed design and labelled it with the materials I intended on using for each element. Firstly, I started to experiment with ProtoPutty, which is a combination of silicone and water to form a soft rubber. During my first experiment, I attempted to mix the silicone with corn starch to help it lose its stickiness, but this ended up causing a mess and did not work the way I expected it to. I then tried to use dishwashing soap as an alternative which was allowed the silicone to become more manageable, and I was able to mould the ProtoPutty into a bowl to create a similar shape. Once it was dried, I could play with the bowl and get a feel for its usability. It was extremely flimsy and whilst it still held its shape, it felt too fragile to be able to hold another silicone bowl on top of it to form a ball. Whilst this stunted my progress, I am still able to use the ProtoPutty to create a mould to use when working with another material such as Resin.

After analysing my features and what I find important to incorporate into my design, I was able to start building my technology. I have decided to use the Arduino to create the functions of Emily due to the ease of accessibility and range of products available that match my functionality. I was able to follow tutorials to assist me in programming my functions to work as I wished. The Arduino can detect the amount of light present in the room and then check for movement whilst also checking the temperature of the room and comparing it to the “outside” temperature. At this point, the outside temperature is only dummy data and will be a function I will have to work on in future iterations. Whilst programming the Arduino, I encountered some obstacles and errors which I was able to resolve after searching for similar answers on forums or by simply taking a step back and looking over my code again. The responses to functions are currently only using light but I plan to incorporate other audible responses in my future iterations.

Interaction Plan

Emily is intended to assist users in changing their energy habits through discomforting responses in a playful, novel device. The user must have the initial desire to change their own habits for Emily to be effective. They may gain motivation from energy bills whether that be due to the high price or the informative graphs given on their bills. With this motivation, the user would then seek a solution to reduce their energy consumption. This is where Emily's purpose can be fulfilled.

The device is intended for use inside the user's house where they desire for a change to be made. Emily is to be placed in a common place around the house that allows all household members to access and benefit from Emily's feedback. To retain consistency and effectiveness, Emily is required to remain powered on and free from large obstructions. This allows the sensors, such as the photosensitive LDR sensor, to gather accurate data rather than skewed data due to any obstruction. As soon as Emily receives power, she will begin to monitor the light and temperature in the room. If Emily believes the user is misusing their energy, she will give consistent alerts to the user to change their behaviour.

Over time the user will subconsciously discontinue their bad habits; whether they remember to turn off the lights before they leave the room, or they only use their air conditioner or heater when there is a significant weather difference to outside. The user will notice a change in their energy bill, and this will encourage them to continue their improved behaviour. The user will become motivated to ensure other household members are also practicing appropriate energy saving behaviours and working together to improve their consumption. A diagram of the user's journey whilst encountering and using Emily can be found in Diagram 1.

Diagram 1: User Journey

Interaction Plan

Emily's interactions are programmed by Arduino. The sensors that are compatible with Arduino are suitable for the interactions that Emily is designed to monitor. Implemented in the system is a photosensitive LDR sensor, a temperature sensor and a dual ultrasonic sensor. These sensors work together to detect if the user is consuming their energy efficiently.

Emily is programmed to continually check for any light present in the room before checking for any movement in the room then comparing the current room temperature to the current outdoor temperature. The interaction diagrams for both features can be found in Diagram 2 and 3. The product will alert the user if they are not being as efficient as they could, and it is up to the user to alter their actions. The user must acknowledge their bad behaviour by touching the snowman's nose. The user does not need to physically acknowledge their good behaviour, but rather is rewarded with silence. These interactions will continue throughout the user's life with Emily, but the frequency of their interactions should lessen as their habits improve.

Emily does not gather information directly from the user but rather from the result of their actions. The device will alert the user of their actions using the lights, and in future iterations through audible responses as well. The only direct interaction the user has with Emily is when they need to 'settle' their incorrect actions by grasping Emily's nose. Afterwards the user should discontinue their bad habit, at least temporarily, allowing only positive responses to appear.

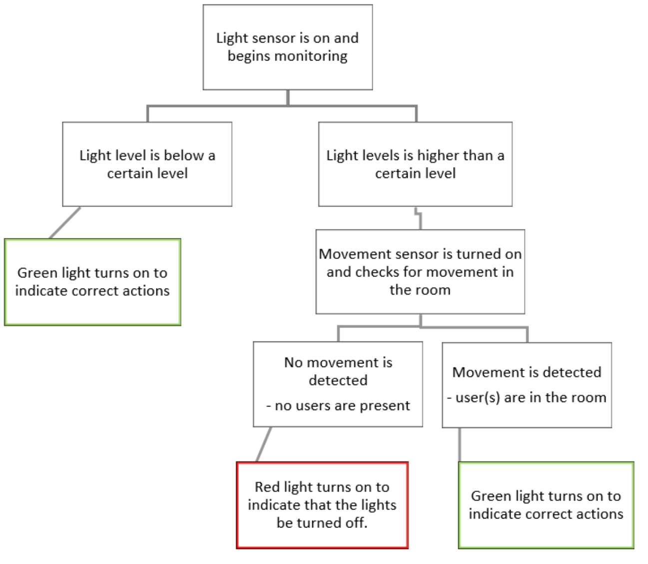


Diagram 2: Light Interaction

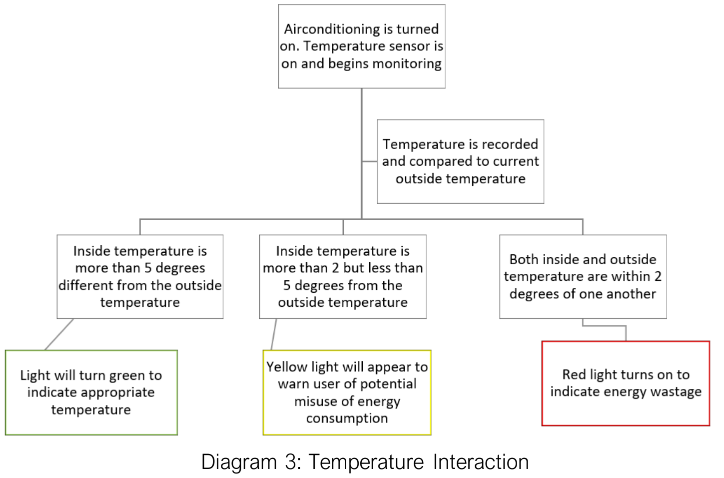


Diagram 3: Temperature Interaction

Project Objectives and Success Criteria

Through the design process, the project is targeted to create a change from the users using methods of discomfort. In order to ensure this is achieved, a list of project objectives and their accompanying success criteria has been created. These will be followed and measured to ensure Emily has a successful outcome. The list can be found in Table 1.

Project Objectives	What factors will make it successful?	How will it be measured?	How often?
The product will make the user feel discomfort when a habit is broken.	The product will give frequent feedback.	Feedback is given within 5 seconds of actions.	Each stage in development
	The feedback given will be in a negative nature.	User acceptance testing to confirm feedback is viewed as negative.	Early stages of development
	The feedback will be noticeable and unable to be ignored by the user creating emotional discomfort for the user.	User acceptance testing to determine levels of discomfort.	During development of feedback
	The user will need to interact with the product to resolve their negative actions thus creating physical discomfort for the user.	User acceptance testing to interactivity and responses to feedback.	During different stages of build
The project will cost no more than $150.	The total for all bills will add up to no more than $150.	Continual accumulation of receipt amounts.	Every purchase
The internal components (i.e. Arduino) will combine smoothly with the external components (i.e. the snowman).	The technical components will be encased in the product.	If there is no components sitting outside of the case.	During end stage of build
	There will be no visible technical components.	The user cannot clearly see inside the casing.	During end stage of build
	The lights will still be visible.	The lights can be seen through the case.	During end stage of build
	The sensors will still be effective but not noticeably visible in the device	The sensors will collect the same data as it does outside the casing.	During end stage of build
The product will accurately read real-time data and the current situation will be considered (i.e. the time of day to decipher natural sunlight from energy powered lights).	The sensors will collect accurate data.	Check data against another source for accuracy.	During each development stage
	The negative impacts for the light sensor will consider the time of day.	Test during both daytime and night-time.	Whilst programming light sensor
	The light sensor will consider any movement in the room.	Test with and without presence in the room.	During end stage of build
The user will be able to connect the product to any power outlet and place it in the position of their choice in their house.	The product will be light weight.	Weight is under 500g.	After build
	The product will be powered by the wall or battery.	Battery can be run by power adapter or battery.	After build
	The product will provide accurate data from any position as long as there are no obstructions and is in a common position.	Check product produces accurate data with different positions and with obstructions.	During end stage of build
The user will increase their awareness of their own energy consumption through the use of Emily.	The user will be able to understand when they are performing incorrect energy usage through visual and audible feedback.	User acceptance testing to confirm feedback is appropriate to assumed reactions.	Before completion of product
	The user will receive immediate feedback to become aware of when their improper consumptions are occurring.	User acceptance testing to ensure appropriate response and actions.	Before completion of product

Table 1: Project Objectives and Success Criteria