Mission Folder: View Mission for 'Aquatech'

State	Virginia
Grade	8th
Mission Challenge	Environment
Method	Engineering Design Process
Students	Saranya Gadwala (1600864) Remi Ladia (Remi_L) Anish Paspuleti (ani123) Advaith Gajulapally (TennisFort)

Team Collaboration

(1) How was your team formed? Was your team assigned or did you choose to work with each other?

Please refer to the document TC_TeamFormation_Aquatech

(2) Provide a detailed description of each team member's responsibilities and jobs during your work on the Mission Folder.

Please refer to the document TC_TeamMemberResponsibilities_Aquatech.
More information about the team responsibilities is also included in Aquatech_Detailed_Research_Document

(3) Did your team face any problems working together? If so, how did you solve them? If not, why do you think you were able to work together so well?

Please refer to the document TC_TeamProblems_Aquatech

(4) What were some possible advantages to working together as a team on this project? How would working as individuals have made this project more difficult?

Please refer to the document TC_TeamAdvantages_Aquatech

Uploaded Files:

- [View] **TC_TeamFormation_Aquatech** (By: Advisor, 02/26/2020, .docx)
  Describes how team was formed
- [View] **TC_TeamMemberResponsibilities_Aquatech** (By: Advisor, 02/26/2020, .docx)
  Describes Team Responsibilities
- [View] **TC_TeamProblems_Aquatech** (By: Advisor, 02/26/2020, .docx)
  Describes Problems Faced by Aquatech
- [View] **TC_TeamAdvantages_Aquatech** (By: Advisor, 02/26/2020, .docx)
  Describes team advantages for Aquatech

Engineering Design

Problem Statement

(1) What problem in your community will your team attempt to solve using the engineering design process? Why did your team choose this problem to try to solve?

Please refer to the document ED_CommunityProblem_Aquatech

(2) Research your problem. You must learn more about the problem you are trying to solve and also what possible solutions already exist. Find AT LEAST 10 different resources and list them here. They should include books, periodicals (magazines, journals, etc.), websites, experts, and any other resources you can think of. Be specific when listing them, and do not list your search engine (Google, etc.) as a resource.

Please refer to the document ED_ProblemResearch_Aquatech, Aquatech_Detailed_Research_Document and "Survey Permission Form"

(3) What did you find out about your problem that you didn't know before? What kinds of possible solutions already exist? Be sure to put this in your OWN words, do not just copy And paste information. Also, be sure to cite your sources.

Please refer to the document ED_ProblemNewInfo_Aquatech

Design Development

(4) What MUST be a part of your solution? These are called the criteria. Explain what criteria are needed to solve the problem. Make sure your criteria are measureable, connected to the problem, and related to your research.

Please refer to the document ED_Criteria_Aquatech

(5) What limits are there on your solution? These are called constraints. Does it need to be a certain size? A certain weight? Is the cost a factor? Write down all of the limits on your solution.

Please refer to the document ED_SolutionLimits_Aquatech

(6) Based on your criteria and constraints, what is your proposed solution to the problem you chose? Explain what it will look like and how it will work. If you can, include a detailed, labeled drawing.

Please refer to the document ED_ProposedSolution_Aquatech

The demo of our prototype is also available below
https://youtu.be/2qA-ZqcuF6A

(7) How will you test your solution? The BEST way to test your solution is to build a working model or a prototype that you can actually use. Or you can guess how your solution will work BASED ON your research. Which method will you use and why?

Please refer to the document ED_TestSolution_Aquatech

Build Model or Prototype

(8) If you built a prototype or model, explain how you built your prototype or model, step-by-step including ALL SAFETY PRECAUTIONS. If you guessed how your solution would work BASED ON your research, explain important information from your research that you used to prove how your solution would work and be sure to cite your sources.

Please refer to the document ED_PrototypeSteps_Aquatech

Test Model or Prototype

(9) Explain how you tested your prototype or model. Be sure to include every step of your testing including all safety precautions that were taken. If not stated it will be assumed no safety precautions were taken. If you are using research to guess how your solution will work, explain step-by-step how it will work and why.

Please refer to the document ED_PrototypeTesting_Aquatech

(10) What problems did you find with your solution? Be specific since you will need to redesign based on these problems.

Please refer to the document ED_SolutionProblems_Aquatech

(11) Describe all of the changes you made to your prototype or model (or proposed prototype) after your first test. Why will these changes improve your solution?

Please refer to the document ED_PrototypeChanges_Aquatech

(12) Present the data you collected from your tests or from your research. If you tested a prototype or model then include all of the numbers you gathered during your testing and all observations you made. Use of graphs and charts is HIGHLY encouraged. If you used research to prove how your solution would work, be sure to include all of the numbers, charts, and graphs you used to make your case. Be sure that all data is related to your solution.

Please refer to the document ED_TestData_Aquatech

(13) What are your potential sources of error? Remember, this doesn't mean "Did everything work?", all tests have potential sources of error, so make sure you understand what that means. Explain how these sources of error could have affected your results.

Please refer to the document ED_SourceOfError_Aquatech

Drawing Conclusions

(14) What conclusions can you draw based on the data you gathered during your tests? Your conclusion should be related to your original problem and your testing, include the data you collected, and refer to your proposed solution.

Please refer to the document ED_Conclusions_Aquatech

Uploaded Files:

- [View] **ED_CommunityProblem_Aquatech** (By: Advisor, 02/26/2020, .docx)
  Describes how team Aquatech chose a community problem.
- [View] **ED_Criteria_Aquatech** (By: Advisor, 02/26/2020, .docx)
  Describes the problem solving criteria by team Aquatech
- [View] **ED_SolutionLimits_Aquatech** (By: Advisor, 02/26/2020, .docx)
  Describes the limitations of the solution by team Aquatech
- [View] **ED_PrototypeTesting_Aquatech** (By: Advisor, 02/26/2020, .docx)
  Describes the Prototype Testing by team Aquatech
- [View] **ED_Conclusions_Aquatech** (By: Advisor, 02/26/2020, .docx)
  Describes the conclusions drawn by the team Aquatech
- [View] **ED_ProblemResearch_Aquatech** (By: Advisor, 02/26/2020, .docx)
  Describes the problem specific research conducted by team Aquatech
- [View] **ED_ProblemNewInfo_Aquatech** (By: Advisor, 02/26/2020, .docx)
  Describes what new information team Aquatech learnt about the problem.
- [View] **ED_ProposedSolution_Aquatech** (By: Advisor, 02/26/2020, .docx)
  Describes the solution design and prototype by team Aquatech
- [View] **Aquatech_Detailed_Research_Document** (By: Advisor, 02/26/2020, .docx)
  This document describes in-depth the research conducted by team Aquatech on various aspect of the problem/design/solution and how they distributed work among themselves.
- [View] **ED_TestSolution_Aquatech** (By: Advisor, 02/26/2020, .docx)
  Describes the testing approaches followed by team Aquatech

- [View] **ED_PrototypeSteps_Aquatech** (By: Advisor, 02/26/2020, .docx)

  Describes the Step-by-Step approach to building the Prototype and Safety Precautions by Team Aquatech
- [View] **ED_SolutionProblems_Aquatech** (By: Advisor, 02/26/2020, .docx)

  Describes the problems faced by the solution used by team Aquatech
- [View] **ED_PrototypeChanges_Aquatech** (By: Advisor, 02/26/2020, .docx)

  Describes the Prototype changes made by team Aquatech
- [View] **ED_TestData_Aquatech** (By: Advisor, 02/26/2020, .docx)

  Describes the data from testing by team Aquatech
- [View] **ED_SourceOfError_Aquatech** (By: Advisor, 02/26/2020, .docx)

  Describes the potential sources of error by team Aquatech

Community Benefit

(1) Explain how investigating the problem your team chose will help the community. Be sure to include the impacts your research will have on individuals, businesses, organizations, and the environment in your community (if any). Make it very clear why solving this problem would help your community.

Please refer to the uploaded file CB_CommunityBenefit_Aquatech

Uploaded Files:

- [View] **CB_CommunityBenefit_Aquatech** (By: Advisor, 02/26/2020, .docx)

  Describes Community Benefit of the product designed by team Aquatech

Mission Verification

(1) Does your Mission Folder project involve vertebrate testing, defined as animals with backbones and spinal columns (which include humans)? If yes, team must complete and attach an IRB approval form.

No

(2) Did your team use a survey for any part of your project? If yes, team must complete and attach a survey approval form.

Yes

(3) You will need to include an abstract of 250 words or less. As part of the abstract you will need to describe your project and explain how you used STEM (Science, Technology, Engineering and Mathematics) to improve your community

The problem that we are trying to address is the third-largest source of water wastage in U.S. households, more specifically, the amount of water used for showers. Many people do not realize the excessive amount of water that is used in the shower.
We would like to reduce water wastage by making people aware in real-time the amount of excessive water they are using in the shower. We started by researching what products are currently available in the market and noticed that even though there are a few products available, they are either very expensive, unsafe or lack all the features to make them a valuable product. After extensive research to design and develop a product that was environmentally friendly, we built a hydro-electricity powered, cost-effect, smart device with cutting edge IoT technology using Arduino IDE. This device not only measures volume of water generated using magnetic sensors and calculates volume using formulas involving the number of rotations, but it can also allow the user to set a threshold to receive an alert with a buzzer as soon as the threshold is met. All the information is saved in the cloud and is displayed real-time through an APP. We were able to successfully operate and test the device and received encouraging feedback from the GMU ECE faculty and Fairfax Water Authority. We are excited that this cost effective product can easily find numerous applications in households, as well as commercial industries such as hospitals, spas, gyms, etc. and many functional uses in the shower, kitchen, lawn irrigation.

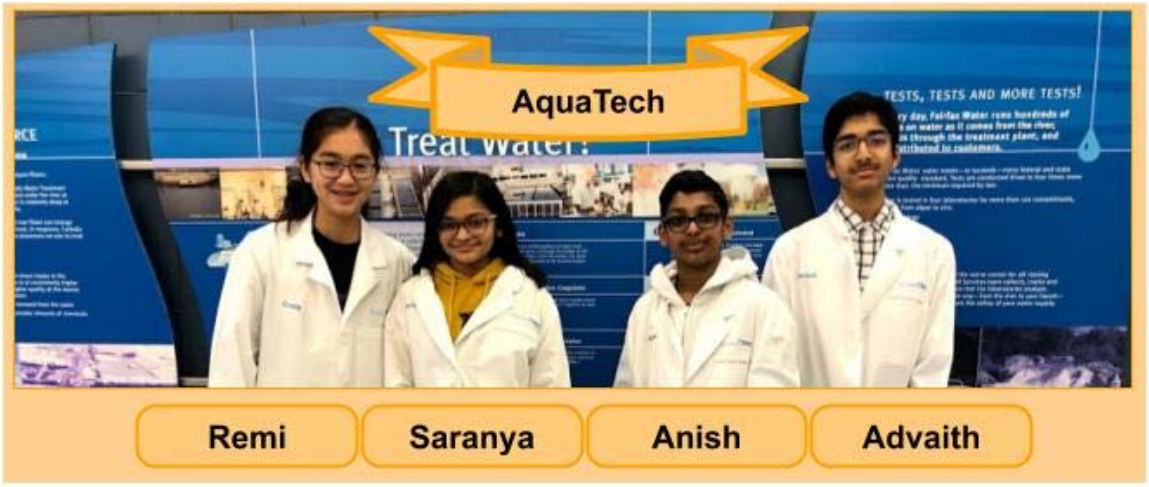
Uploaded Files:

- [View] **Survey Permission Form** (By: Advisor, 01/30/2020, .pdf)

  Attaching the ecybermission Survey approval form and IRB Form for the Aquatech team with the needed signatures

How was your team formed? Was your team assigned or did you choose to work with each other?

We choose to work on this project together because we have been friends since elementary school with similar interests in STEM-related projects that have a positive impact on our community. A few years ago, some of us (Saranya, Anish, and Remi) participated in the Science Olympiad. This experience and opportunities to work on school projects together allowed us to collaborate and realize that we complemented each other's work styles and strengths. A family friend, who participated in eCybermission, recommended the competition to us as a great learning opportunity. We were immediately interested in the challenge mission because we could use our STEM knowledge to find innovative solutions to help solve problems. From our perspective, what really set eCybermission apart from other competitions was how each team has the opportunity to select a problem to work on, instead of working on a problem that was already chosen for us. The main reasons that we decided to work together for this project were our similar interests in STEM, making a difference in our community, and as a bonus, having fun while learning.



Provide a detailed description of each team member's responsibilities and jobs during your work on the Mission Folder.

A guiding principle that we considered throughout the two phases of our project, is to evenly split responsibilities and jobs among our eCybermission team so that everyone can contribute different ideas and leverage each other's strengths.

Phase 1: During the Brainstorming/Researching Phase, we work collaboratively to assign four main roles:

1) The person in charge of the meeting

- Ensures everyone has an opportunity to talk and share their ideas
- Guides the discussion from the status of assignments to additional topics that need further research
- Steers the discussion to remain focused on the meeting's agenda and objectives

2) The Secretary

- Works with parents and schedules additional meetings to fit everyone's availability, as needed
- Checks status of assignments and reminds others to finish, if not completed
- Helps point out important points in the discussion to help the Notetaker capture the agreed upon decisions and actions

3) The Notetaker

- Takes detailed notes regarding the information presented during the meeting
- Gives out assignments based on the discussions and any additional information that should be researched

4) The Computer Controller

- Controls the computer connected to the TV, to present the information being discussed and evaluated during the meeting
- Displays the information or research completed for discussion
- Provides information to questions that may come up during the meeting

We periodically rotate these responsibilities so that everyone can contribute to each aspect of the project and gain an understanding to provide feedback. Although these are the individual roles, we all ask questions, actively participate in the discussions, and challenge each other to get to the best solution. At the end of the meeting, we are given assignments from the Notetaker, which includes research topics and mission folder writing. By using this system of allocating assignments to each team member at the end of each meeting, we are able to accomplish a lot and progress quickly through the research phase, which included conducting our own research and surveys.

Phase 2: During the Building Phase, additional roles were added that were more technical in nature such as programming, building, and researching.

1) The Programmer

- Creates a program to meet the project objectives using the Arduino IDE software for a task

2) The Builder

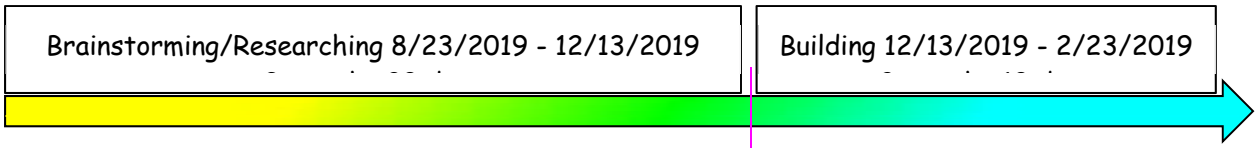
- Works on the breadboard, solder (with parental guidance) and comes up with the design of the specific parts of the model.

3) The Researcher

- Determines how to progress with the project, appropriate sequencing of tasks, and the issues that require research.

Since there is mostly hands-on work during this phase, the roles are somewhat flexible because there were many times when we were all programmers troubleshooting to fix a coding error, all builders connecting components to complete the circuit, or all researchers to find best alternative solutions to our issues.

Below is the timeline of the two phases of our project:



Below is our documentation of our project, and what we accomplished at every meeting.

Date	Tasks finished and HW	Next Steps
8/23/2019	- Think about additional solutions for existing problems - Research if the solutions we came up with already exist - Propose additional problems and innovative solutions	- Propose additional problems - Come up with rankings of problems - Narrow down top 3 and select problem for project All
8/29/2019	Vote on rankings or problems during meeting and propose criteria for our product	All (2 - 3 each)
9/7/2019	- How to measure the flow of water/how does the water company / appliances track water usage	Advaith
	- How to connect the water meter with the wifi transmitter	Remi
	- Measure/research the usage of shower water compared to the total household water consumption	Saranya
	- Research safety concerns for coupling water meter with battery-operated sensor/transmitter- hydroelectricity / powered by light-sun/backup power	Anish

	- Research all available products in the market with similar criteria and functions	All
	- Propose team names	All
9/14/2019	- Talk to Ecybermission advisors coaches about product/questions we have	All
	- Team registration	Team Advisor
	- Research the additional questions/thoughts we came up with during meeting	All
9/20/2019	- Research equipment for trying the hydrometer & wifi sensor and inform the team advisor of our selections to purchase.	All
	- Purchase equipment to start tests	Team advisor
	- Find AT LEAST 10 different research resources and list them here. They should include books, periodicals (magazines, journals, etc.), websites, experts, and any other resources that can provide additional information for our project. Be specific when listing them, and do not list your search engine (Google, etc.) as a resource.	All - everyone does minimum 2 - 3
	- What kinds of possible solutions already exist? Be sure to cite your sources.	All - everyone does minimum 2
9/27/2019	- How to make beeper work	Anish
	- Wifi chip to app communication	Advaith
	- How to make it safe	Remi
	- How to measure water rotations	Saranya
	- Google docs - instead of normal text subheading	add mission folder sections
10/4/2019	- Advaith will consult with experts to decide on microcontroller s/w, affordable, simple	Advaith
	- Make the hydro-generator product work and power 5v light	Saranya
	- Power Screen/vibrator to the chip	Anish
	- APP development for IoT connected devices	Remi

10/25/2019	- Add more detail to mission folder task - Contact IoT experts and find out how to get started, what chips & s/w to use for simple/inexpensive IoT project - Try out IoT APP software	Advaith
	- Add more detail to mission folder task - LED screen to chip connectivity - Contact IoT experts and find out how to get started, what chips & s/w to use for simple/inexpensive IoT project - If time permits try out IoT APP software	Anish
	- Add more detail to mission folder task - Try out IoT APP software, come up with a simple app - Contact IoT experts and find out how to get started, what chips & s/w to use for simple/inexpensive IoT project	Remi
	- Add more detail to mission folder task - Buy the bulb for hydroelectric generator and make it work with the outside faucet, shower pipe - Contact IoT experts and find out how to get started, what chips & s/w to use for simple/inexpensive IoT project - If time permits, Try out IoT APP software	Saranya
	Product considerations: -Inexpensive -Simple/Practical -Small -What do you think is the best way to connect a small device to an app	
11/22/2019	https://ece.gmu.edu/research-interests/internet-things-iot	Advaith
	Find nearby university IoT professors and email them to get their input/suggestions	Anish, Remi, Saranya
	https://sing.stanford.edu/site/publications/tethys-iotdi18.pdf	Everyone
	Review the above	
	Respond to the professor and ask for compatible Apps	Everyone
	Research more universities that specialize in IoT and contact Professors	Anish/Advaith
11/29/2019	Research https://store.arduino.cc/usa/nano-33-ble	Everyone

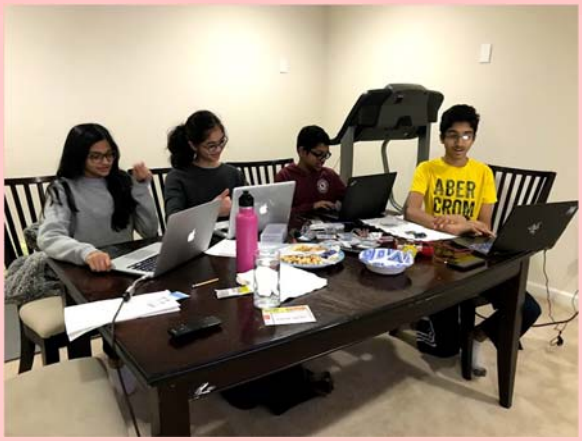
	Arduino ESP32 - research, if we can use it for our purpose	Anish
	Reference video: https://www.youtube.com/watch?v=8GLXSebQVCE	
	Arduino Nano 33 IoT - research	Remi
	Arduino IDE	Saranya/Everyone
	https://www.youtube.com/watch?v=Wkt28joEJUE	
	compatible part/bulb for hydroelectricity Gen	Advaith
12/13/2019	https://www.instructables.com/id/DIY-ESP8266-WiFi-Water-Sensor-With-Text-and-Email-/	All Review
	https://www.amazon.com/gp/product/B00L083QAC/ref=as_li_ss_tl?ie=UTF8&linkCode=sl1&tag=intorobo-20&linkId=881b4c12ed8940c572842632079fe28e	All Review
	https://www.intorobotics.com/pick-right-bluetooth-module-diy-arduino-project/	All Review
	https://www.youtube.com/watch?v=KQR2d_u7knQ&feature=youtu.be	All Review
	https://drive.google.com/open?id=18ScxDfzauLnovafoQNfdIRB2OwbshrclYvv	All Review
1/1/2020	Online surveys - Think of additional questions and add them below	All Review
	How many people in the family	
	How many showers in the house	
	How many times a day you shower	
	how much time you spend in the shower in a single-use	
	Are you concerned about how much water you or your family is using	
	Would you like to track shower usage	
	How much are you willing to pay for a smart shower water sensor	
	Would you be willing to cut down your shower water usage to conserve water	
	What do you think is the right amount of time to spend in the shower	

	Do you already own a shower tracker	
	If yes how much does it cost	
1/9/2020	https://ece.gmu.edu/research-interests/internet-things-iot	
	Find nearby university IoT professors and email them	Anish, Remi, Saranya, Advaith
		Remi's Survey: https://www.surveymonkey.com/r/CHFGLHP
	4 separate surveys - google form or survey monkey	bit.ly version http://bit.ly/WaterConservation101
		Advaith's Survey http://bit.ly/ShowerTime1
		https://advaithgajulapally.typeform.com/report/id8Kqv/6bhQisgCEWu3wTWO
	Advaiths Results---->	https://docs.google.com/spreadsheets/d/1RJx8x1XDRs2NFMAwF3kD-OSKXh91p8XxjdmehRyoYOs/edit#gid=608921448
	Anish's survey ---->	https://docs.google.com/forms/d/e/1FAIpQLSdLvrttzhes8jxLZJisfangInnLakZTNf-BzfdZmjJdHzDv

		rg/viewform?usp=sf_link
	Saranya's survey —>	https://forms.gle/6JeSpiPk5Dw5QhGj7
	Remi Survey ---->	https://www.surveymonkey.com/r/CHFGLHP
1/14/2020	Change the survey fields to number only/limit text fields as much as possible	Everyone
	Send the survey to the maximum number of contacts	Everyone
1/18/2020	Research how to make a threshold for the buzzer to sound	Everyone
1/24/2020	Research other possible apps to display data	Advaith/Anish
	Learn more about how to customize the Blynk App	Saranya/Remi
	Continue working on Mission folder and update prior topics as needed	All- work on assigned mission folder questions
1/30/2020	First meeting	
1/31/2020	List of things to buy on sat:	All- Add more if any are missing
	soldering wire	
	Powerboost 1000c	
	3.7-volt lipo battery	

	https://www.youtube.com/watch?v=iueWEkM6cuQ	
2/5/2020	http://help.blynk.cc/en/articles/512056-how-to-display-any-sensor-data-in-blynk-app	URLs for Blynk programming/virtual pins
	All - research/try out Blynk if possible and add the links below:	
	:http://help.blynk.cc/en/articles/512061-what-is-virtual-pins	
	https://examples.blynk.cc/?board=ESP8266&shield=ESP8266%20WiFi&example=GettingStarted%2FPushData	
	https://iotdesignpro.com/projects/temperature-humidity-monitoring-over-blynk-app-using-esp8266-and-dht11	
2/10/2020	Tasks:	
	Focus on the Mission folder and complete all the assigned Questions.	All
	Research how to connect hydroelectric generator and lipo battery to Powerboost 1000c	Anish and Advaith
	Any way to fix loose connections, and make them permanent, other than soldering. Think of ways to make the design smaller and sleeker	Saranya and Remi
2/19/2020	Visit George Mason University to update Dr. Cameron Nowzari (Professor), and Joseph Matthew Prince (Ph.D. student) on the status of our project. Also, attend the IoT Demo presented by Dr. Nowzari's students.	All
2/24/2020	Visit Fairfax Water and spoke with Erica Fox and Mukesh Inamdar	All
2/25/2020	Submit the Mission Folder	
2/26/2020	Challenge Mission Accomplished!	

Remi and Saranya drawing a diagram of the first prototype plan, with help and pointers from Anish and Advaith.

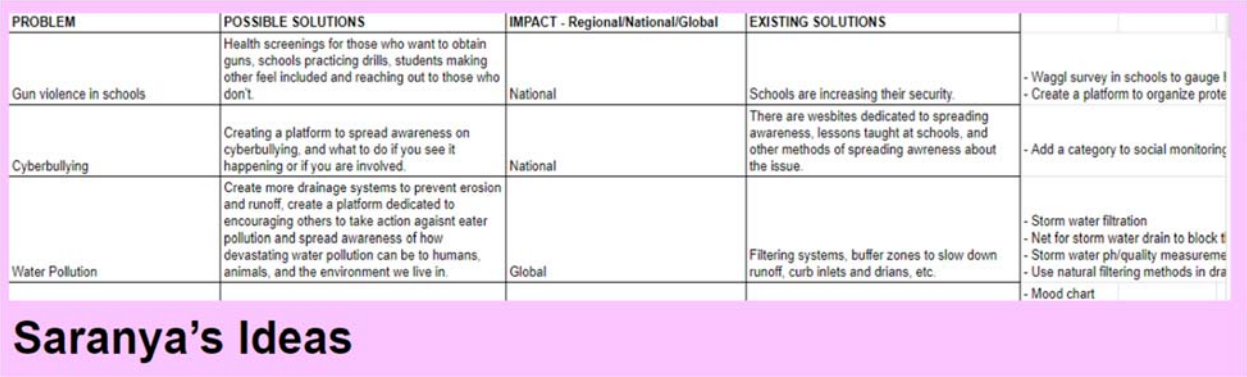


After the brainstorming stage, we all sat together at a meeting to research the C coding language and write the code.

Did your team face any problems working together? If so, how did you solve them? If not, why do you think you were able to work together so well?

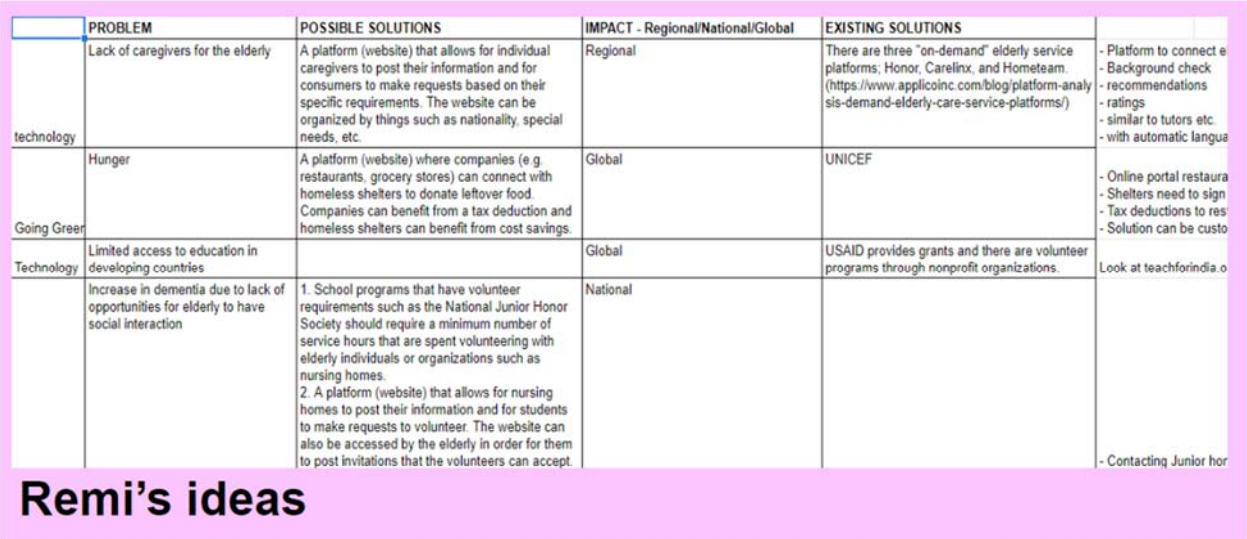
Our team did not encounter many problems working together, and when we did, it was only a disagreement early in our journey while deciding which topic (problem) to choose, however, we solved it rather quickly. A few examples of challenges that we encountered included:

1) At the beginning of our project, all of us researched a few topics that we wanted to solve as a team. Eventually, each of us researched the topic we felt the strongest about and presented our research and proposed solutions to each other. Anish wanted to solve high water usage, Remi thought that the lack of caregivers for the elderly was concerning, Saranya wanted to defend against cyberbullying, and Advaith wanted to conserve electricity.



PROBLEM	POSSIBLE SOLUTIONS	IMPACT - Regional/National/Global	EXISTING SOLUTIONS	
Gun violence in schools	Health screenings for those who want to obtain guns, schools practicing drills, students making other feel included and reaching out to those who don't.	National	Schools are increasing their security.	- Waggl survey in schools to gauge t - Create a platform to organize prote
Cyberbullying	Creating a platform to spread awareness on cyberbullying, and what to do if you see it happening or if you are involved.	National	There are wesbites dedicated to spreading awareness, lessons taught at schools, and other methods of spreading awreness about the issue.	- Add a category to social monitorin
Water Pollution	Create more drainage systems to prevent erosion and runoff, create a platform dedicated to encouraging others to take action agaisnt eater pollution and spread awareness of how devastating water pollution can be to humans, animals, and the environment we live in.	Global	Filtering systems, buffer zones to slow down runoff, curb inlets and drians, etc.	- Storm water filtration - Net for storm water drain to block t - Storm water ph/quality measureme - Use natural filtering methods in dra
				- Mood chart

Saranya's Ideas



	PROBLEM	POSSIBLE SOLUTIONS	IMPACT - Regional/National/Global	EXISTING SOLUTIONS	
technology	Lack of caregivers for the elderly	A platform (website) that allows for individual caregivers to post their information and for consumers to make requests based on their specific requirements. The website can be organized by things such as nationality, special needs, etc.	Regional	There are three "on-demand" elderly service platforms; Honor, Carelinx, and Hometeam. (https://www.applicoinc.com/blog/platform-analysis-demand-elderly-care-service-platforms/)	- Platform to connect e - Background check - recommendations - ratings - similar to tutors etc. - with automatic langua
Going Green	Hunger	A platform (website) where companies (e.g. restaurants, grocery stores) can connect with homeless shelters to donate leftover food. Companies can benefit from a tax deduction and homeless shelters can benefit from cost savings.	Global	UNICEF	- Online portal restaura - Shelters need to sign - Tax deductions to res - Solution can be custo
Technology	Limited access to education in developing countries		Global	USAID provides grants and there are volunteer programs through nonprofit organizations.	Look at teachforindia.o
	Increase in dementia due to lack of opportunities for elderly to have social interaction	1. School programs that have volunteer requirements such as the National Junior Honor Society should require a minimum number of service hours that are spent volunteering with elderly individuals or organizations such as nursing homes. 2. A platform (website) that allows for nursing homes to post their information and for students to make requests to volunteer. The website can also be accessed by the elderly in order for them to post invitations that the volunteers can accept.	National		- Contacting Junior hor

Remi's ideas

A	B	C	D	E	F	G
Going Greer	High Water Usage	- Design Faucets, Sprinklers, etc. that reduce the total water usage. According to the United States Environmental Protection Agency, about 20% of the water usage is in the shower. One solution can include "Smart Showers" that can pace yourself, so you don't waste too much water.	Global	There currently aren't a lot of solutions to this problem, however there may be products on the market that tackle this issue.	- Awareness of amount of water being used: Built-in timer in the shower head. Water usage statistics - monitoring, alerting. sm - Timer to shutdown sprinkler after certain time. - Soil moisture sensor {Since there are products such as these, we should find the diameter of the water tube, find the average amount of gallons it can pump out per minute, and program an app that can track you and your families gallons used in the shower} --According to many websites, the average flow is 2.1 gpm, and we could create a simple app that would track the length of showers for the entire family. If someone spent 8 minutes in the shower, then 2.1 x 8 is equal to 16.8 total gallons used. In the app, we could also display the total average # of gallons used by all users of the app.	water meter +
Technology	Package Theft	An idea is to design a small inexpensive tracker to figure out where someones package is, which is placed at the warehouse before shipping. This may allow packages to be tracked on an app, so the customer may know where there package is. According to many websites, the current barcode tracker used by shipping companies, such as USPS are unreliable and often display the incorrect status of a shipment. The use of a cheap tracker may display the exact placement of a package, as well as where it could be if it was stolen.	National	The current solutions are things like Amazon Key where they deliver packages in home.	- Inexpensive tracker inside mail packages as an alternative to barcode for altering the customers if there is package theft or when delivered. Option to pay extra shipping for adding the tracker for valuable/secure mail. - Luggage tracker - Reusable/eco-friendly/re-cyclable/inexpensive solution - incentives for returning the trackers	Cost in trasmi
		According to a speech by Richard Moe(president of the National Trust for Historic Preservation) on November 30, 1996, Moe called sprawl a "destructive, soul-less, ugly mess." Sprawl is development that destroys communities, and many government entities have adopted laws that mandate sprawl. Some solutions for this issue is to use more sensible land-use planning, and				

Anish's Ideas

Mission	PROBLEM	POSSIBLE SOLUTIONS	IMPACT - Regional/National/Global	EXISTING SOLUTIONS	
Energy Conse	**overusage of lights**	small inexpensive override switch that closes and opens a circuit automatically after a certain time. We can associate this with a desktop or computer with a relatively simple code and be able to change the values for how long the lights should stay on before automatically turning off. If we do further this idea after prototyping the program on computer we can try to follow some relatively simple tutorials to change it into a app form with one function, being changing values for each light. Instead of modifying the circuit in the wall or ceiling all we would have to do is modify the circuit by taking out the manual part. The only problem with this is we would have trouble keeping bot the automatic and manual circuit.	IDK	Using compact fluroscent lightbulbs, dimmers, motion sensors, timers	programmable electric
	Climate Change				
	Public Safety				

Advaith's ideas

We voted and ranked each topic based on the following categories: team interest, feasibility, impact, and cost.

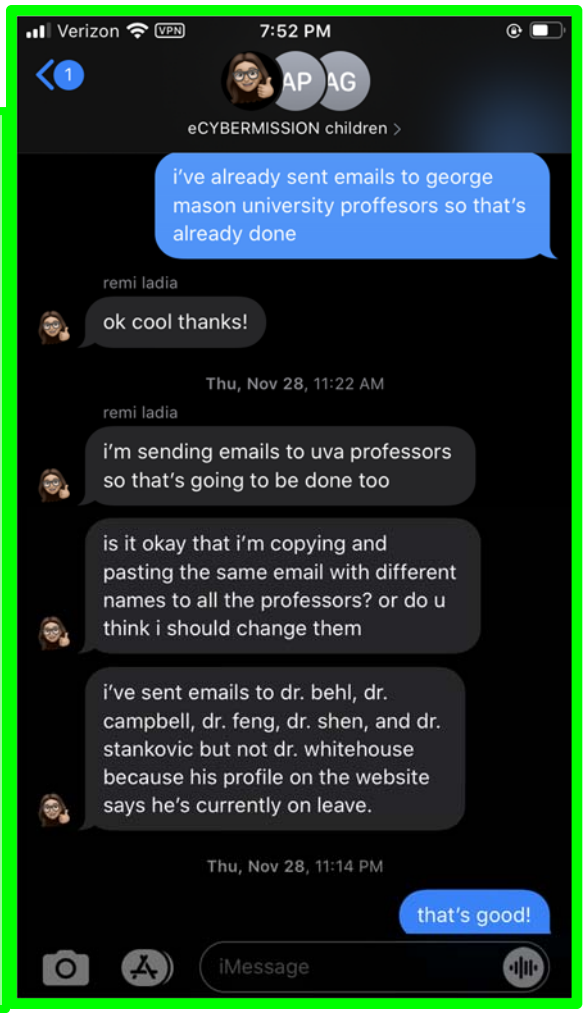
Advaith	Sum of each row	Ranking(1-11)	Anish	Sum of each row	Ranking(1-11)	Total Sum:		
Overusage of lights	13.5	#7	Overusage of lights	14.5	#7	Overusage of lights	43	43
High Water Usage	17.5	#1	High Water Usage	19.5	#1	High Water Usage	59.5	59.5
Package Theft	13	#8	Package Theft	15.5	#5	Package Theft	40.5	40.5
Sprawl	8.5	#11	Sprawl	8	#11	Sprawl	24.5	24.5
Lack of caregivers for the elderly	16.5	#3	Lack of caregivers for the elderly	17	#3	Lack of caregivers for the elderly	58.5	58.5
Hunger	15.5	#4	Hunger	17	#2	Hunger	55.5	55.5
Limited access to education in developing countries	12	#9	Limited access to education in developing countries	11.5	#10	Limited access to education in developing countries	41.5	41.5
Increase in dementia due to lack of opportunities for elderly to have social interaction	15	#5	Increase in dementia due to lack of opportunities for elderly to have social interaction	17	#4	Increase in dementia due to lack of opportunities for elderly to have social interaction	50	50
Gun violence in schools	11	#10	Gun violence in schools	11.5	#9	Gun violence in schools	36.5	36.5
Cyberbullying	17	#2	Cyberbullying	13	#8	Cyberbullying	49	49
Water Pollution	14	#6	Water Pollution	15	#6	Water Pollution	51	51

At the end, we voted for Anish's smart water idea. We were able to work in such a cohesive manner because all four of us shared similar interests like STEM, helping the environment, and approached the selection with an open mind. We can also attribute our success of working well as a team to the fact that many of us have had experience with working together, such as the Science Olympiad, robotics, and school projects. These experiences have taught us how to work with people that have different opinions to create a sustainable and agreed upon solution. Although we disagree from time to time on what topics to focus on or what approaches to use, we learn to agree on a compromise by explaining our individual points of view and understanding everyone's perspectives.

2) Finding available times for all four of us to meet was a big challenge. In addition to school, we all have extracurricular activities like enrichment classes, Model United Nations, tennis, Science Olympiad, etc. In order to address this dilemma, we created a group chat so we could communicate together real-time and eventually found that meeting on a weekly basis on Fridays around seven o'clock PM worked for all of us. However, there were a few weeks where we couldn't meet due to completing priorities such as preparing for exams, competitions, or holidays. During the weeks that we were not able to meet, we wanted to respect everyone's priorities so we made a plan of what we could work on individually at home during our free time. Sometimes, when one person couldn't make it, the rest of us worked on another aspect of the project and provided the team member with an update. Creating the group chat to communicate with each other really helped us continue to make progress on the project when we were not available to meet in person.

Here is a screenshot of the group chat we used. This chat was very helpful to us when discussing the following:

- What times we were available to meet.
- What we should be completing at home.
- Filling in members who couldn't make it to a meeting on what we completed and what they can work on.
- Asking each other questions to clarify areas of confusion.
- Where to meet whenever we took a "field trip"



3) Our team had differing skills and experience such as some of us did not know how to program. However, this provided each team member with an opportunity to help each other learn something new. For skills that were new to all of us, we learned to be resourceful by going to the library to check out books or looking for helpful videos to watch and learn together.

What were some possible advantages to working together as a team on this project? How would working as individuals have made this project more difficult?

Throughout the project, there were many cases where working together made things easier. As a group, we were able to work through problems and contribute our individual strengths for the betterment of the whole team. While Anish and Advaith were better at understanding the circuit and code, Saranya and Remi were stronger at writing and organization. We were able to help each other understand the new concepts that we were discovering and problems we were. In the end, we all learned programming with Arduino, connecting circuits, transmitting information to the app, etc. When one person couldn't make it to a group meeting, the others were able to help that person catch up on what they missed. The diverse talents and interests in our group allowed for each of us to participate in a project that was engaging and interesting for us all.

If we had worked individually, the project would have taken much longer because we would not have had the benefit of each team member's unique knowledge and diverse perspectives. Additionally, there are some aspects of the project we might not have perfected or fixed if we weren't working together in a group. Though our different ways of thinking occasionally caused slight disagreements, working through those differences of opinions enabled us to become closer and have a better understanding of each other.

Every aspect of our project required teamwork, all the way down to just deciding which real-world problem meant the most to us. Originally, the issue of conserving water was Anish's idea, but we all felt that it was the right choice for our group. While researching the topic, we found helpful and interesting information that we could use in the project. When we encountered problems with the code, we benefited from Anish and Advaith's past computer programming experiences to come up with solutions. Even small things such as scheduling weekly meetings were something we worked on as a team; our conflicting schedules made it difficult, but we were able to overcome that barrier as well.

We all agree that working as a group is better than working individually. If we had worked alone, the project may not have been as fun or successful. We made many great memories of working together on this project. It was an interesting project that we all learned a lot and benefited from. We are all so thankful to have been able to have this experience and glad that we chose to work together.

Remi and Anish discuss what topics they are both proposing while Saranya is in the “Computer Controller” role and looking through the spreadsheet of everyone’s ideas. (In this meeting, we were still at the beginning stage where we were brainstorming what topic to do and the solutions).

What problem in your community will your team attempt to solve using the engineering design process? Why did your team choose this problem to try to solve?

When we began working on the eCybermission project, every person on our team thought of a few ideas of what to solve. In order to identify the problem that we wanted to solve, we voted on the different ideas from the team members.. The voting was also based on the impact to the community at a global/national/regional scale and the feasibility to come up with an effective solution to the problem considering our experience and skill set. Our team chose to work on the issue of over usage of water in the shower and the need for water conservation. We felt that out of all the topics this was the most effective one provides the best value. When first learning about how much water was used in the shower we were amazed. We found out that an average American uses 17.2 gallons for each shower. This is the third largest use of water in America.

The following is the list of problems we considered and how we voted on each. Highlighted in red are the top 3.

High Water Usage	59.5
Lack of caregivers for the elderly	58.5
Hunger	55.5
Water Pollution	51
Increase in dementia due to lack of opportunities for elderly to have social interaction	50
Cyberbullying	49
Overuse of lights	43
Limited access to education in developing countries	41.5
Package Theft	40.5
Gun violence in schools	36.5
Sprawl	24.5

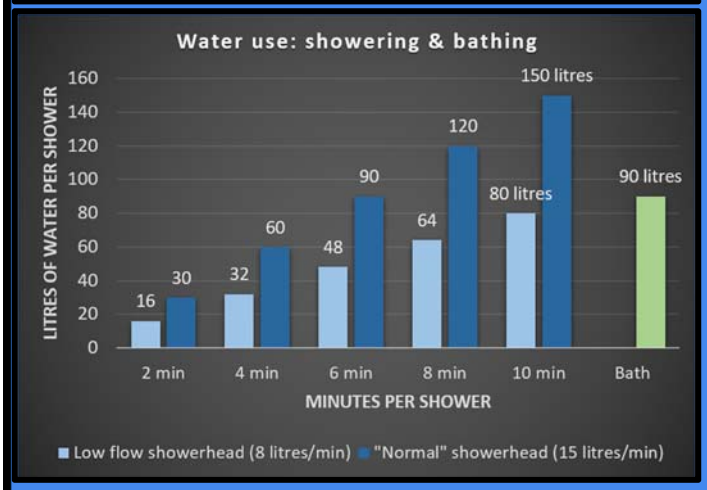
Here is our voting worksheet in detail. We ranked everyone’s ideas and we calculated which idea had the highest weight, which happens to High Water Usage.

	A	F	G	H	M	N	O	P	Q	R
1	Advaith	Sum of each row	Ranking(1-11)	Anish	Sum of each row	Ranking(1-11)	Total Sum:			
2	Overusage of lights	13.5	#7	Overusage of lights	14.5	#7	Overusage of lights	43	43	
3	High Water Usage	17.5	#1	High Water Usage	19.5	#1	High Water Usage	59.5	59.5	
4	Package Theft	13	#8	Package Theft	15.5	#5	Package Theft	40.5	40.5	
5	Sprawl	8.5	#11	Sprawl	8	#11	Sprawl	24.5	24.5	
6	Lack of caregivers for the elderly	16.5	#3	Lack of caregivers for the elderly	17	#3	Lack of caregivers for the elderly	58.5	58.5	
7	Hunger	15.5	#4	Hunger	17	#2	Hunger	55.5	55.5	
8	Limited access to education in developing countries	12	#9	Limited access to education in developing countries	11.5	#10	Limited access to education in developing countries	41.5	41.5	
9	Increase in dementia due to lack of opportunities for elderly to have social interaction	15	#5	Increase in dementia due to lack of opportunities for elderly to have social interaction	17	#4	Increase in dementia due to lack of opportunities for elderly to have social interaction	50	50	
10	Gun violence in schools	11	#10	Gun violence in schools	11.5	#9	Gun violence in schools	36.5	36.5	
11	Cyberbullying	17	#2	Cyberbullying	13	#8	Cyberbullying	49	49	
12	Water Pollution	14	#6	Water Pollution	15	#6	Water Pollution	51	51	

Remi	Sum of each row	Ranking(1-11)	Saranya	Sum of each row	Ranking(1-11)
Overusage of lights	8	5	Overusage of lights	7	#5
High Water Usage	11.5	2	High Water Usage	11	#1
Package Theft	6	7	Package Theft	6	#6
Sprawl	4	8	Sprawl	4	#11
Lack of caregivers for the elderly	12	1	Lack of caregivers for the elderly	13	#2
Hunger	10	3	Hunger	13	#4
Limited access to education in developing countries	9	4	Limited access to education in developing countries	9	#9
Increase in dementia due to lack of opportunities for elderly to have social interaction	8	5	Increase in dementia due to lack of opportunities for elderly to have social interaction	10	#3
Gun violence in schools	7	6	Gun violence in schools	7	#10
Cyberbullying	10	3	Cyberbullying	9	#7
Water Pollution	12	1	Water Pollution	10	#8

The following table and graph provides information on the average water usage for a given length of time, based on the sources below.

People showering/Day	Showerhead GPM	Shower Time	Daily Use	Weekly Use	Monthly Use (approx.)	Annual Use
4	1.5	10 min	60	420	1,820	21,840
4	2.5	10 min	100	700	3,033	36,400
4	5.0	10 min	200	1,400	6,067	72,800



The picture at the top gives a representation of how many gallons a family of 4 uses. The bottom picture shows how many litres showering uses.

Additional information on the water usage:

https://www.poweroptimal.com/cost-shower-south-africa/

https://www.home-water-works.org/indoor-use/showers

https://www.conservationmart.com/blog/index.php/measuring-shower-water-usage-helps-save-water/

What MUST be a part of your solution? These are called the criteria. Explain what criteria are needed to solve the problem. Make sure your criteria are measurable, connected to the problem, and related to your research.

In order to solve the problem of shower water wastage, we needed to come up with a way for people to measure and track their water usage. Only by having this kind of information would people be able to understand and take the necessary action to reduce water waste. Our solution was to build and program a device that could collect information about the amount of water used and the time spent in the shower. Below are some of the criteria we felt would be needed to be part of our solution:

- Mobile application: A way to view, store, and track the data being collected about the shower.
- Water measurement display: A visual way to display the amount of water used during a shower, i.e. the number of liters of water used.
- Shower time display: A visual way to display the time spent in the shower, i.e. the number of seconds that the water has been running.
- Water usage alarm: A visual and audible way to alert the person taking a shower that some limit had been met or exceeded.
- Physical safety: The shower device should be safe to use with water, i.e. waterproof and/or shockproof.
- Data safety: The data collected about the user should be kept private and secure. Ensure that there is no personal data collected and that data is only accessible by the user.
- Data accuracy: The measurements, including water volume and time, should be accurate.
- Cost effectiveness: The cost of the device should be less than or about the same as other available comparable products. Based on our research the cost of related products were well over $100 dollars.
- Hydroelectric power: The device should be able to produce some or all of the power it needs to run. Our research showed that some power could be produced by available hydroelectric components.
- Minimal external power requirement: The device should be able to run on minimal power such as that supplied by a small battery.
- Wireless connectivity: Except for power, the device should be able to connect wirelessly for accessing or sending data.
- External endorsement: In researching related products, we found that an endorsement from a reputable sponsor could help with product adoption. This is one of the reasons we reached out to and connected with the Fairfax Water authority.

What limits are there on your solution? These are called constraints. Does it need to be a certain size? A certain weight? Is the cost a factor? Write down all of the limits on your solution.

Through the process, there were many factors that we considered while building our smart shower sensor. First, we want the device to be as small as possible, so it fits nicely and is a clean design. A long design will lower the showerhead, so we attempted to keep the design as short as possible. It is also a human tendency to admire products that look nice, so we attempted to enhance the look.

Since electricity and water can result in serious danger, another constraint we had was to come up with a design/system where water won't come into contact with electricity. To do that, we plan on using tupperware (to encase the circuitry), silicone tubing (for the cables) and waterproof sealant (prevent water seepage) in the future. We also took into consideration that electricity itself is dangerous, so we decided to use 5V power to keep users safer.

Another limitation we had was to minimize the cost of our smart shower tracker because we found that many related products were well over $100 dollars. Our team wanted to create something that was more affordable, as lower-cost means that the product will be available to a larger number of people, creating a larger impact in the world.

One of the biggest constraints we had was regarding power. Although powering this device with a battery is straight forward, we decided to use a hydroelectric generator to produce energy from the shower as power. At first, our group decided to run solely on water power, but we found that it takes time to supply the power to our module. After interviews with a college professor and a Ph.D. student, we decided to add a 5V LiPo battery as backup power to transmit data for the entire shower period.

Explain how you tested your prototype or model. Be sure to include every step of your testing including all safety precautions that were taken. If not stated it will be assumed no safety precautions were taken. If you are using research to guess how your solution will work, explain step-by-step how it will work and why.

When testing our prototype we made sure to stay safe by using electrical tape, maintaining our distance and learned how to properly solder with our parent's supervision. To work toward our prototype we had 6 main mini-projects. The projects were connecting the Arduino to an app called Blynk using the built-in wifi chip, testing our active buzzer, learning about how the hall effect sensor worked and made pulses, using a flow meter with a built-in hall effect sensor to see how the sensor worked, using the count command to count the number of rotations for 1 liter of water, and syncing the whole project with the Blynk App.

We tested our prototype by screwing it into a valve in the laundry room. Then, we would look at the data we were getting from the Blynk app. We tested each individual aspect of our project as shown below.

Our first ever project involved an led, a 100ohm resistor, and a few jumper wires. Once we got the circuit ready we learned how to connect to an app using the chip. To do this we entered the wifi and password into the code. We also generate an authorization token from the app that we put into the code. In the app, we inserted a button that when pressed turned on.

Our next project was a simple project using software on the computer called MQTT box. We had a very basic circuit and code. When we send a one to the system the buzzer would go on and when we sent a 0 it would turn off.

Our third project involved a hall effect sensor. When a magnet came near the hall effect sensor the hall effect would send a pulse, which we could see in the serial plotter. We discovered that it was easier to get a prebuilt flow sensor and then attach it to the hydroelectric generator. We tested how the flow sensor worked by blowing into it. Whenever someone would blow, the readings in the serial monitor would go straight to 1024 and we saw peaks and valleys in the serial plotter corresponding to the rotations.

In our next project, we found out that we could count the number of rotations by using the count command in the Arduino ide. Next, in order to find out the number of rotations the flow sensor went through for 1 liter we set up an experiment. We had a one-liter jug. We turned on the water and when the jug filled up we saw how many rotations it took using the serial plotter. After several trials, we determined that for one liter the flow sensor took 200 rotations. We used this value as a base for the rest of our projects.

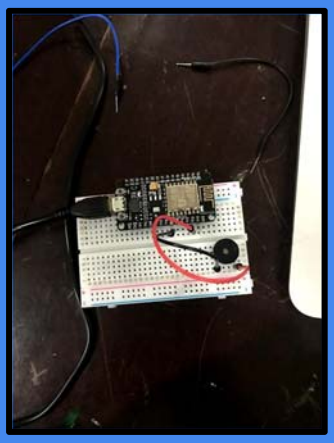
Afterward, in the program, we wrote that if the sensor passes a certain amount of rotations the active buzzer would sound.

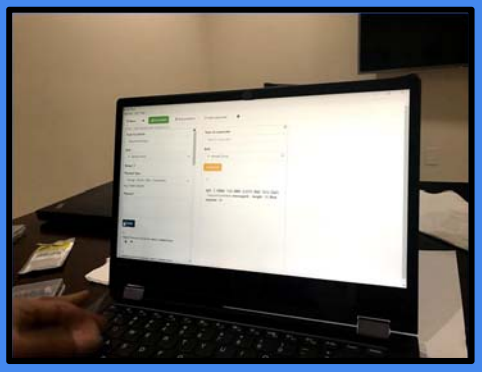
Finally, we connected the ESP8266 to the Blynk App and started making widgets on it. In the app, we made the data update in intervals of 5 seconds. The data would then go to the app and be displayed on a gauge. We also soldered the ground lines to the Powerboost 1000c and the USB

female adapter to the Powerboost. We stayed safe by taking help from our parents for the soldering.

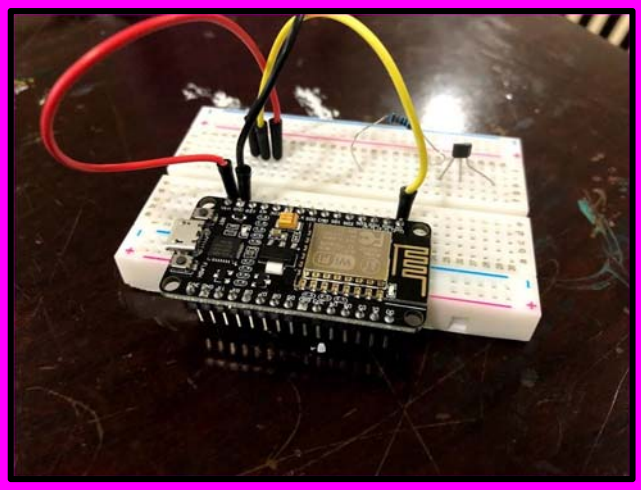
In the picture we are measuring the number of rotations the hall effect sensor took for 1 liter. After several trials we found our that the sensor took 200 rotations for every liter.

This was our first ever project using Blynk. We had a simple circuit where if a button is pressed in the app a led turns on.

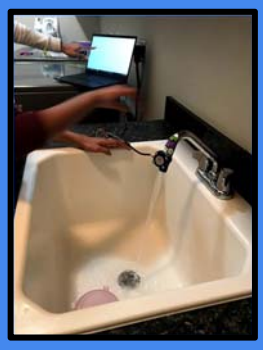




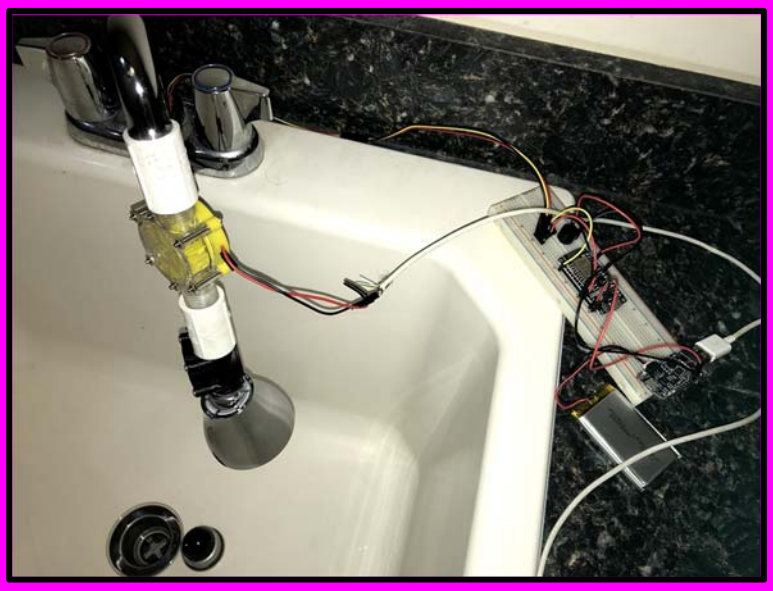
This was our first circuit using the active buzzer. On the right is a picture of the software we used for the buzzer called MQTT Box



On the left is a picture of our first ever circuit using a hall effect sensor. Using a serial monitor we learned about how the hall effect sensor functioned.



This was our first time using the prebuilt flow sensor. There is a hall effect sensor inside the sensor. We were able to find out that for every 200 rotations the hall effect sensor made, one liter went through the sensor. Every time the hall effect sensor came the wave would peak in the serial



This was our final prototype with everything plugged in.

What conclusions can you draw based on the data you gathered during your tests? Your conclusion should be related to your original problem and your testing, include the data you collected, and refer to your proposed solution.

Answer:

The smart shower tracker is our solution we came up with to reduce the amount of water used by people in the shower. This product alerts the user when 79 liters, which is equal to approximately a 10 minute shower, have been used. We relied on the survey results and other research to conclude that 10 minutes is the average recommended shower time. A large component of our project was the repeated testing of our device where the buzzer activated when it reached a threshold, and synced the data to the app reliably. From the results in our survey, we observed that about half of our survey participants tend to take longer showers than necessary. Not only do long showers increase water consumption, but they also increase water bills. Results from our survey showed that almost all of the participants are open to the idea of reducing their water usage, meaning that the product would likely be spread throughout various communities, creating a larger impact. Although our final product was fully functional, there were many challenges we overcame along the way. These challenges offered plenty of learning experiences and produced numerous versions of our model. Through our experience, we are thankful that we had the opportunity to talk with a Ph.D student, a college professor, and chemists at Fairfax Water, who were helpful and provided valuable feedback, as well as answered any questions that we had. Our original goal was to create a device capable of reminding people to cut down on their showers by an alarm, while tracking water usage and sending it to an app. All of these criteria have been met by our final product. All in all, our project has been an extremely knowledgeable experience for all of us, and we know that the hours dedicated on our device was time well spent.

Even after this project, we plan to spread the smart shower tracker concept to different areas in the household such as sprinklers or faucets. Some other changes we would like to make in the future include the device playing short melodies as a two minute warning before the buzzer activates, incorporating a temperature sensor, and decreasing the cost of product. So far, our main project goals have been satisfied, and we know that raising awareness about our project will allow people to be more wary of their water consumption.

Research your problem. You must learn more about the problem you are trying to solve and also what possible solutions already exist. Find AT LEAST 10 different resources and list them here. They should include books, periodicals (magazines, journals, etc.), websites, experts, and any other resources you can think of. Be specific when listing them, and do not list your search engine (Google, etc.) as a resource.

The problem that we are trying to combat is the overuse of water, and specifically saving household shower water. Many people spend an excessive amount of time in the shower, wasting a lot of water. Our goal is to conserve water, and we can take a step forward by targeting water usage in the shower. Showers are the third-largest form of water use in the American home and we would like to reduce shower water usage by making people aware of how much water they are using. For example, there are already numerous shower timers, such as The Shower Manager, which cuts the water flow by two-thirds when the time is up. Other options are also currently on the market, such as the plentiful products on Amazon, but many of these options are unreliable or even dangerous. Our aim is to create a product that not only tracks and alerts the users, but one that is safe, eco-friendly, and cost-effective, so that we can conserve water in a way that does not endanger our well-being, respects the environment and has a reasonable cost so that we can maximize the number of people that use it, multiplying the impact.

Products That Already Exist in the Market:

- Magee, Christine. "FLUID Is A Smart Water Meter For Your Home." *TechCrunch*, TechCrunch, 15 Sept. 2015, techcrunch.com/2015/09/15/fluid-is-a-smart-water-meter-for-your-home/.
- "Shower Manager – The Automatic Shower Timer." *Shower Manager – The Automatic Shower Timer*, www.showermanager.com/.
- "WaterSmart Technology." *"We Make Water Conservation Personal"*, 2 Aug. 2018, watersmarttechnology.com/product/showersmart/.
- "The World's Smartest Showerhead." *Waterhawk*, beawaterhawk.com/.
- "WaterSmart Technology." *"We Make Water Conservation Personal"*, 2 Aug. 2018, watersmarttechnology.com/product/showersmart/.

Websites:

- "Showerheads." *EPA*, Environmental Protection Agency, 15 Apr. 2019, www.epa.gov/watersense/showerheads.

This is where we gained our statistics on how much shower water is used and how much it makes up of all the water being used in households.

- Roberts, Nick, and Nick. "Developing Apps for the Internet of Things." *Crowdsourced QA Testing Company*, www.globalapptesting.com/blog/developing-apps-internet-of-things-iot.

This resource especially helped us in the beginning of our project where we learned about what IoT was and how it could help us solve the problem of water wastage.

- Balkan, David. "How A Water Meter Works Determines Your Water Bill." *Balkan Plumbing*, 31 Dec. 2019, www.balkanplumbing.com/how-a-water-meter-works-types-reading/

This website helped us more about water meters, like how they work, how to read it, how to find a leak, and different types of meters.

- Dykes, Allanah. "How Does a Water Meter Work?" *Hunker*, Hunker.com, 25 Sept. 2018, www.hunker.com/13416502/how-does-a-water-meter-work.

This website also helped us broaden our knowledge of water meter types and how they work. We also learned what a water counter was and where water meters are located.

- "01 How to Read Your Water Meter." *Smart Home Water Guide*, www.smarthomewaterguide.org/how-to-read-your-water-meter.

This website had a very detailed step-by-step process to read a water meter.

- *Total Water Use*, www.usgs.gov/mission-areas/water-resources/science/total-water-use.

This website helped us understand the scale of how much water is being used every day.

- "Button Cell." *Wikipedia*, Wikimedia Foundation, 31 Jan. 2020, en.wikipedia.org/wiki/Button_cell.

This article helped us look at the different types of batteries we could use to power our project.

- Lowe, Doug. "Electronics Components: How the 555 Timer Chip Works." *Dummies*, www.dummies.com/programming/electronics/components/electronics-components-how-the-555-timer-chip-works/.

This website helped us understand how the 555 chip works and where we could use it.,

- Instructables. "DIY ESP8266 WiFi Water Sensor With Text and Email Alerts." *Instructables*, Instructables, 7 Sept. 2017, www.instructables.com/id/DIY-ESP8266-WiFi-Water-Sensor-With-Text-and-Email-/.

This website helped us understand how to set up libraries in the arduino IDE. We also learned how to receive updates from the arduino.

- *Introduction to MQTT*, learn.sparkfun.com/tutorials/introduction-to-mqtt/all.

This website helped us understand how to use MQTT Box. We were using this software for the first time on our active buzzer program.

- "How to Display ANY Sensor Data in Blynk App." *Blynk Help Center*, help.blynk.cc/en/articles/512056-how-to-display-any-sensor-data-in-blynk-app.

This website helped us understand how to properly display data from our prototype in our app using Blynk.

Experts:

- Erica Fox and Mukesh Inamdar Chemists at Fairfax Water. We discussed the biggest problems related to water that the country is facing. What measures are effective in conserving fresh water.

Paper:

- Chiang, Holly, et al. *Tethys: Collecting Sensor Data Without Infrastructure or Trust*. Stanford, sing.stanford.edu/site/publications/73. This document was referred to us by Dr. Campbell from the University of Virginia. The document described how a wireless water flow sensor called Tethys can collect data without relying on additional sources.

Before we meet with Joseph, we emailed his professor, Dr. Cameron Nowzari. All of us emailed different experts from different places to see if we could get some advice on our project.

Who we emailed:

Saranya: Professor Nowzari, IoT Innovators, Dr. Jabbari, Dr. Sasan

Remi: Dr. Behl, Dr. Campbell, Dr. Feng, Dr. Shen, Dr. Stankovic

Anish: Mark Rober

Our emails with Dr. Nowzari and Joseph:

Saranya Sai Gadwala <ssgadwala@gmail.com> Nov 24, 2019, 5:42 PM

to cnowzari, Hima

Dr. Nowzari,

Hello, we are middle school students and we are trying to conserve water by designing a device that measures and tracks shower water usage using a BlueTooth or Wifi enabled transmitter. We are also trying to create an app that generates reports using this data. We were wondering what IOT chips we should use that would be the most cost-effective, easy to program, and appropriate for this use. We were wondering if we could consult with you in an appointment to discuss IOT.

Thank you,
Saranya Gadwala, Remi Ladia, Advaith Gajulapally, Anish Paspuleti

Cameron Nowzari cnowzari@gmu.edu via gmuedu.onmicrosoft.com Nov 26, 2019, 12:02 PM

to me, Hima

Hi Saranya,

I'm happy to help in some way but need a lot more details here. What school are you with? What exactly is this project for/what time of timeline are we looking at?

If you'd just like to come check our our lab and ask some questions to my PhD students in the lab you are more than welcome to do that. The timing is not great though as next week will by my last week available on campus until mid/late January.

Best,

Cameron

Saranya Sai Gadwala <ssgadwala@gmail.com> Dec 5, 2019, 5:52 PM

to Cameron

Hi Dr. Nowzari

Thank you for the response. Sorry for the delay in responding as we were out of town last week.

We are from Rocky Run Middle school and this project we are working on is for Ecybermission competition. We basically have some ideas to design a smart shower water monitor that measures water, transmits information to an App. Through the App, we want to give the user the option to set thresholds when crossed a vibrator is activated to alert the user. For doing all these we want to use a good and cheap IoT board that is easy to program. And we need your help in selecting the right product and software and some tips on how to get started as we are new to IoT programming.

We would be very excited to come to your lab, check out the work that is going on, and also to chat with the Ph.D. students, given an opportunity.

We are available to come after school (after 3 pm) on weekdays starting 12/12/2019.

Please let us know when is the best time.

Thank you very much!
Saranya Gadwala, Anish Paspuleti, Advaith Gajulapally, and Remi Ladia

•••

Hi Saranya,

Sounds great! What about a timeline?

Our finals week is next week and then we are off for break so your timing right now isn't great. Our classes don't resume until January 21st so I wouldn't be able to meet with you until at least then. If that's okay then please just email me again in 5-6 weeks to schedule an appointment then. Otherwise I can put you in touch with some PhD students but again I cannot guarantee any sort of availability over winter break

Best,

Cameron

Cameron Nowzari cnowzari@gmu.edu via gmuedu.onmicrosoft.com Dec 11, 2019, 5:08 AM

to me, Hima

We can meet with you towards the end of January when the semester begins again. Please email me next month to schedule an appointment if that's what you'd like to do.

Best,

Cameron

Saranya Sai Gadwala <ssgadwala@gmail.com> Jan 22, 2020, 10:36 AM

to Cameron, Hima

Dr. Nowzari, Happy New Year! As discussed previously we wanted to contact you to schedule a time to come and meet you to discuss our project . Wondering if you are available on 1/27, 1/28 or 1/29 evening after 3pm please.

Thank you for your time!
Saranya Gadwala, Remi Ladia, Anish Paspuleti, and Advaith Gajulapally

Cameron Nowzari cnowzari@gmu.edu via gmuedu.onmicrosoft.com Jan 22, 2020, 11:25 AM
to me, Hima

Hi Saranya,

If you're available at 5 PM tomorrow that would be ideal. Otherwise I will get back to you after our lab meeting tomorrow.

-Cameron

Saranya Sai Gadwala <ssgadwala@gmail.com> Jan 22, 2020, 6:23 PM
to Cameron, Hima

Dr. Nowzari

Thank you for the email and upon checking with my team looks tomorrow may not be the best. Wondering if we can meet early next week if possible please. Sorry about it. Appreciate your help very much!

thank you

Cameron Nowzari via gmuedu.onmicrosoft.com Jan 27, 2020, 12:58 PM
to Joseph, Hima, me

Hi Joseph,

I have some students here from Rocky Run Middle School working on an IoT-type project and they have a few questions that you can probably help with.

Could you please briefly meet with them sometime this week? I think they are generally available after 3 PM so if you can just send them some times you know you will be in the lab that should be sufficient.

Thanks!

-Cameron

Saranya Sai Gadwala <ssgadwala@gmail.com> Jan 27, 2020, 10:25 PM
to remi, anish.paspuleti, advaithgajulapally, Joseph, Cameron, Hima

Thank you Dr. Nowzari and Dr. Matthew. We were wondering if we could come at 3:30 p.m. on Thursday. Thank you so much for your time!

Saranya Gadwala

Joseph Prince Mathew via exchangelabsgmu.onmicrosoft.com Jan 29, 2020, 12:25 AM
to me, Cameron

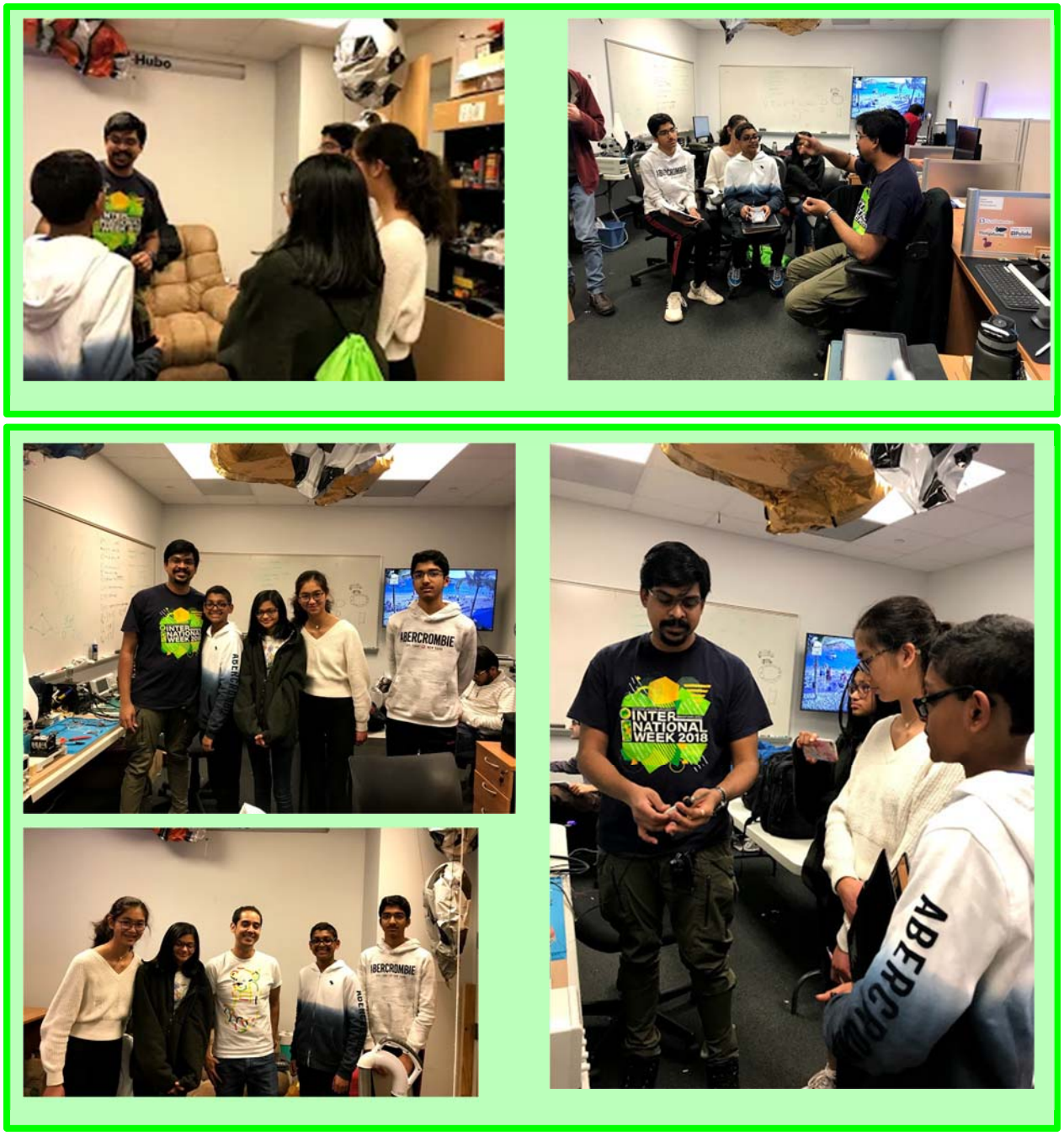
Hi Saranya
Sure. Thursday at 3:30 pm works. Please let me know when you are on campus.

Regards,
Joseph Prince Mathew

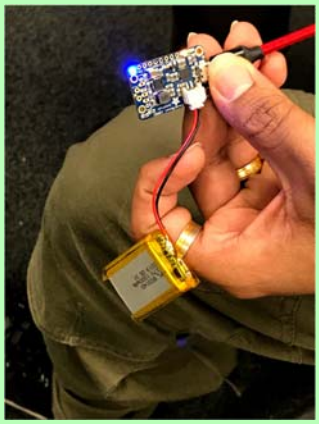
•••

Interview with Joseph Matthew Prince (Ph.D. student at George Mason University):

We met with Mr. Joseph who is a Ph.D. student at George Mason University, Electrical and Computers Engineering Department. With his permission, we voice recorded our discussion. The interview was very interactive. Our team shared the detailed design of our solution including all the components we had planned to use. Mr. Joseph provided a lot of tips especially in the area of precautions to build our equipment safely and effectively.



Pictures from our trip on January 30th.

Here are photos of the Lipo battery that Mr. Matthew recommended us to use for more power. After this meeting was when we purchased a Lipo battery and started using it in our project.

Programming language:

- The programming language being used
- How the data is to be transferred to the app/cloud
- Usage of WiFi (team explained how WiFi was used)
- Usage of app like Blynk

Design:

Self Contained system:

- All detection needs to happen using ESP8266
- Will detect the amount of water being used and will have logic internally to determine whether to stop the shower or send a signal to the user to stop the shower
- Send messages to the app with the information of water being used, time to complete the shower

Power generation and usage:

- The team asked if power generated from the shower can be stored and used later
- Mr. Joseph indicated that it is doable, it but would require a more robust design of a power regulation system and may be a bit more ambitious for the scale of this project

Sustainable power supply:

- The power generated by water flow may not be enough and sustainable
- A lipo battery could be used as a backup

Measuring the water flow:

- Hall effect sensor to measure the number of rotations that correlates to the amount of water flowing

Safety/Precautions:

- 5V is not high enough to be dangerous to be handled by the team
- Lipo batteries are not safe if bent/stretched/pierced. Keep it away from any sharp objects to avoid accidental explosion
- Soldering - is not safe for kids to solder, and recommended to be done by adults
- Cautioned on the limits of voltage that can be passed

- Usage of a diode to throttle the voltage to avoid burning out of the circuit

Apps:

- Suggestions on apps that can be used (MIT App Developer, Get apps from Android Studio)
- The team has picked Blynk app for ease of use

What did you find out about your problem that you didn't know before? What kinds of possible solutions already exist? Be sure to put this in your OWN words, do not just copy and paste information. Also, be sure to cite your sources.

During the course of this project, we discovered a lot of new information about different aspects of our topic. We had to research ways to measure the flow of water, how to measure the use of shower water compared to the total consumption of water, and we also researched any safety issues that could possibly arise. Through this project, we also discovered many new types of software and technology. For example, we found and tested multiple different circuits that we didn't previously know about or understand. Prior to this project, we were not aware that the recommended shower time is between five to ten minutes. This project also gave us more insight about how much water people waste by taking such long showers and how big of an impact it has on the environment.

We also came across a few other products that achieve some of the things that we are trying to achieve but did not include all aspects of our project objectives. For example, one product that we found can measure water usage, but it is designed to be used in a sink instead of in a shower. Another product measured and displayed water usage in a shower, but it had a warning that stated that the product contained lead and could possibly poison you. Other options were merely timers and did not keep track of the amount of water being used. We decided that we needed to create a reliable, safe option so that people can properly track the length of their showers and the amount of water that they use during a shower.

Below is a shower timer that lacks some of the necessary components that we wanted to incorporate such as a way to measure the amount of water used and an app that can display the data collected.

Amazon.Com, 2020, https://www.amazon.com/Sunsbell-Waterproof-Temperature-Humidity-Bathroom/dp/B07PB8GHV7/ref=sr_1_2?keywords=shower+timer&qid=1568481694&s=hi&sr=1-2. Accessed 26 Feb 2020.

Below is another timer, but it does not show the accurate amount of time used. Though it is cheap, it is most likely also low-quality and unreliable. It also does not show the amount of water that has been used.

Amazon.Com, 2020, https://www.amazon.com/Bathing-Sandglass-Management-Bathroom-Accessory/dp/B07JNFSPX3/ref=sr_1_13_sspa?keywords=shower+timer&qid=1568482803&s=hi&sr=1-13-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExRkZUQThQRlpPUVpaJmVuY3J5cHRlZElkPUEwMzcxMjI0MU4xWVBWMk1HTUlTNSZlbmNyeXB0ZWRBZElkPUEwMzA5ODk3M1FJNklaMk1RMUlOSyZ3aWRnZXROYW1lPXNwX210ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU=. Accessed 26 Feb 2020.

The product below, called ‘The Shower Manager’, helps the user shorten their time in the shower by decreasing the flow of water by ⅔ when time is up. Additionally, it has an alert tone that sounds sixty seconds before the time is up. However, the product is not yet available for purchase and it does not show how much water has been used.

Amazon.Com, 2020, https://www.amazon.com/Enerlites-HET06A-White-1-5-10-15-20-30-Countdown-Decorator/dp/B00IB0ZJXE/ref=sr_1_10?keywords=shower+timer&qid=1568482803&s=hi&sr=1-10. Accessed 26 Feb 2020.

We also found a professional shower timer called ‘ShowerSmart’. It cuts shower times and saves water. The product is for sale at $119.95; much more than many people would be willing to pay for a shower timer.

“WaterSmart Technology.” *"We Make Water Conservation Personal"*, 2 Aug. 2018, watersmarttechnology.com/product/showersmart/

Though all of these products had pros and cons, none of them were able to achieve everything that we were hoping to. By researching products such as these, we were able to get a better idea of what we need to achieve in order to make our product stand out.

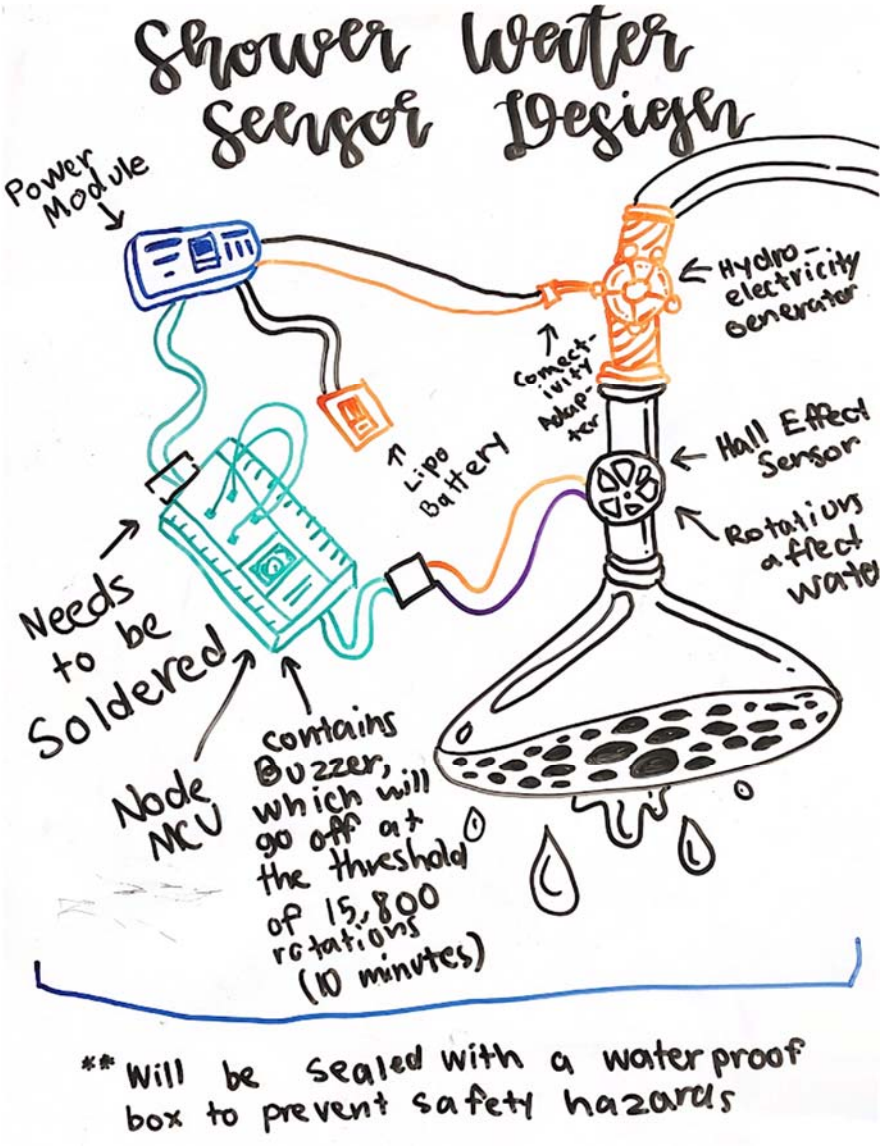
Based on your criteria and constraints, what is your proposed solution to the problem you chose? Explain what it will look like and how it will work. If you can, include a detailed, labeled drawing.

When we chose to find a way to address the problem of water wastage, we knew that we wouldn't be able to stop the overuse of water entirely; however, one of the places where people waste the most water is in the shower. Based on our research, designing a shower head that can alert the user when a certain amount of time has passed or measure how much water was used is potentially an expensive, complicated task. Instead, our proposed solution was to design a device that would be:

1. simple, compact, and easy to attach to the shower head;
2. affordable for the user;
3. able to alert the user with a sound when a set amount of minutes have passed;
4. compatible with an app that is connected to the device via BlueTooth or WiFi to display the data collected by the device;
5. easy to navigate and use; and
6. (most importantly) safe and functional.

Even though we experienced many issues while creating our device, we eventually overcame them by working together, being resourceful and perseverant, and thinking outside the box.

Below is the diagram depicting our eco-friendly design



Here is a walkthrough of our design by all the team members.

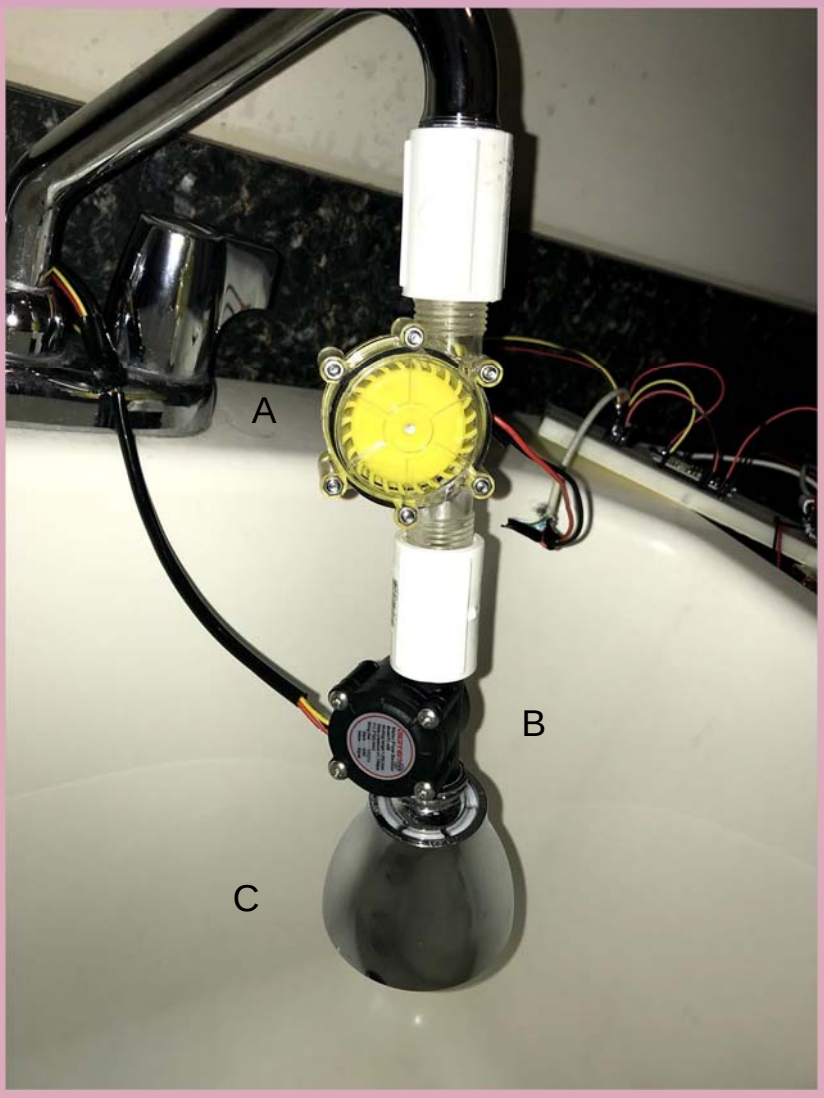
https://youtu.be/2qA-ZqcuF6A

Final Design:

Here are the pictures from our final design.

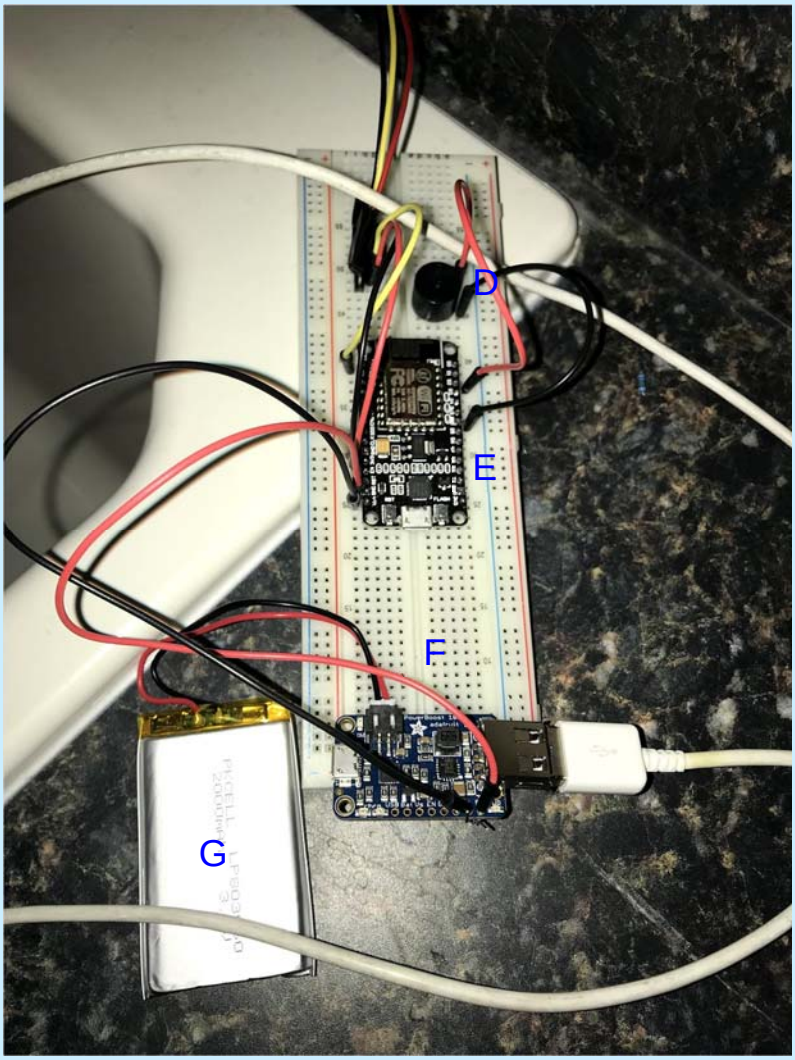
Image1: This is the comprehensive view of the prototype of our device

Image2: Here, the hydroelectricity generator is connected to the water flow meter which is then connected to the showerhead. Since we could not find a product that is both a hydroelectricity generator and a hall effect sensor, we had to use the components separately. In the future, we plan to design a compact integrated hall effect sensor and hydroelectricity generator.



A- Hydroelectricity Generator
B - Water Flow Meter
C - Shower Head

Image3: Shows the detailed circuits and connections



D - Active Buzzer

E - ESP8266

F - Powerboost 1000c

G - LiPo Rechargeable battery

In the picture above, the hydro-electricity generator(A) is connected to the Adafruit 1000c powerboost (F) via USB cable. We had to do this as the generator had a 2-pin JST connector and we could not connect it directly to the powerboost. So we removed the 2-pin JST connector and soldered the USB cable to the generator(A) wire.

1. A rechargeable battery(G) is connected to the Powerboost (F) using the compatible adapter and will ensure that there is a steady supply of power to the device.
2. 5V and GND pins from powerboost are connected to ESP8266 (E) VIN and GND pins respectively, to power the chip.
3. The active buzzer +/- pins are connected to ESP8266 on pins D2 and GND.
4. Hall Effect sensor (Water flow meter) is connected to ESP8266 on pins A0 (pulse), 3V and GND.

Programming was done using Arduino IDE and C language. At a high level here is our program logic.

- Define Threshold and other variables
- **myTimer Procedure:**

  If water is flowing, calculate the seconds and liters and send to the Blynk app
- **Setup Procedure:**

  Define the ports for Active Buzzer & Hall Effect sensor

  Start the Blynk Program using the Wifi Credentials

  Start myTimer function to be invoked every second to send information to the Blynk app
- **Loop Procedure:**

  Count the rotations in the Hall Effect Sensor within the flow meter

  If the count exceeds the threshold, fire the buzzer

  If the count remains the same, stop the buzzer

Blynk app Configuration:

We used the Blynk app to read and report on the sensor data. We used Blynk as it is an easy drag and drop interface with many types of useful widgets that can be configured to read sensor data from ESP8266 virtual pins. Widgets are configured to refresh at 1 sec interval.

Image1: Shows the design of the app and all the widgets involved. Gauge, Labeled Display and Graph widgets have been used.

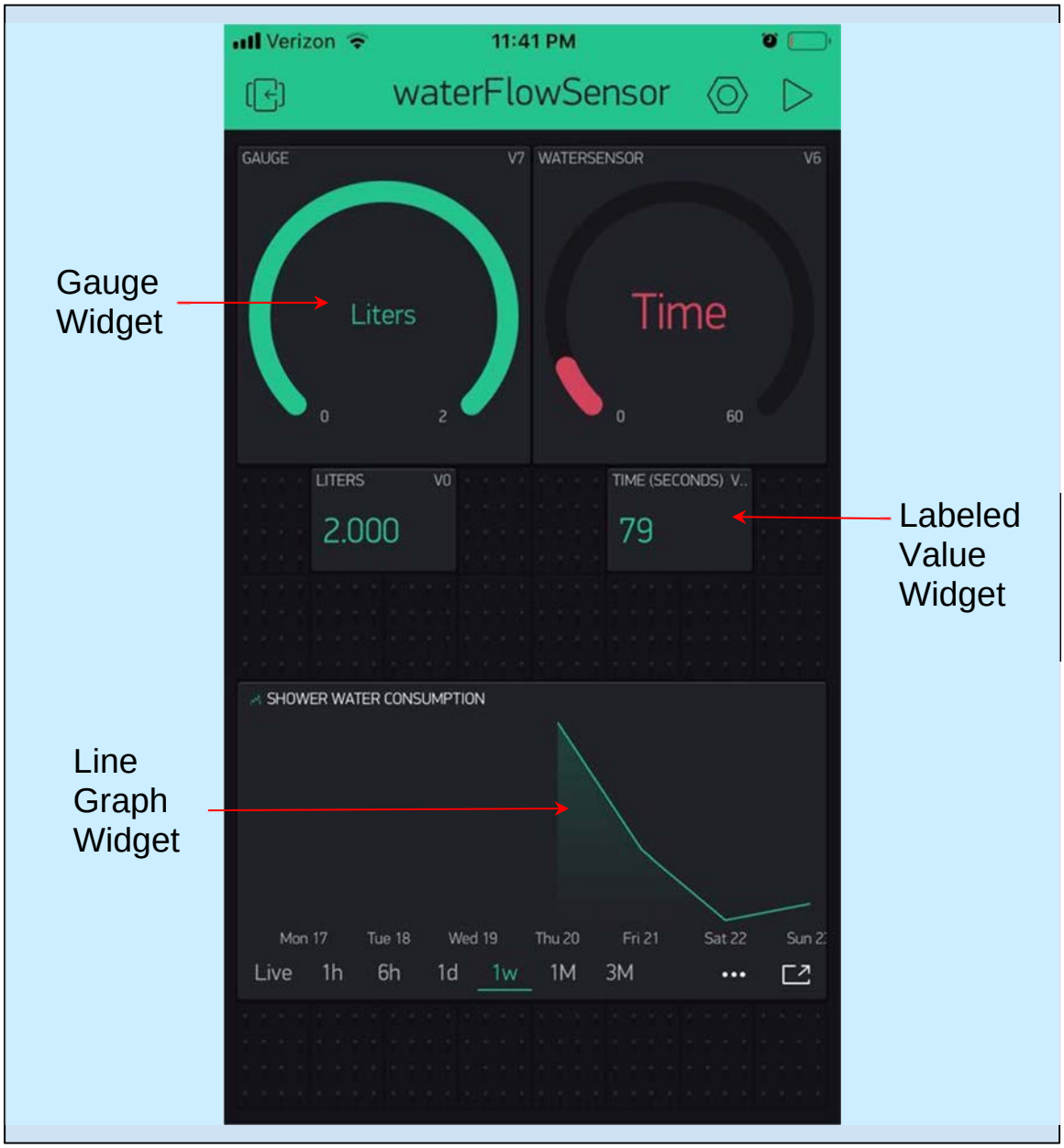


Image2: Shows how the Gauge widget for Liters is configured to read input from virtual pin V7.

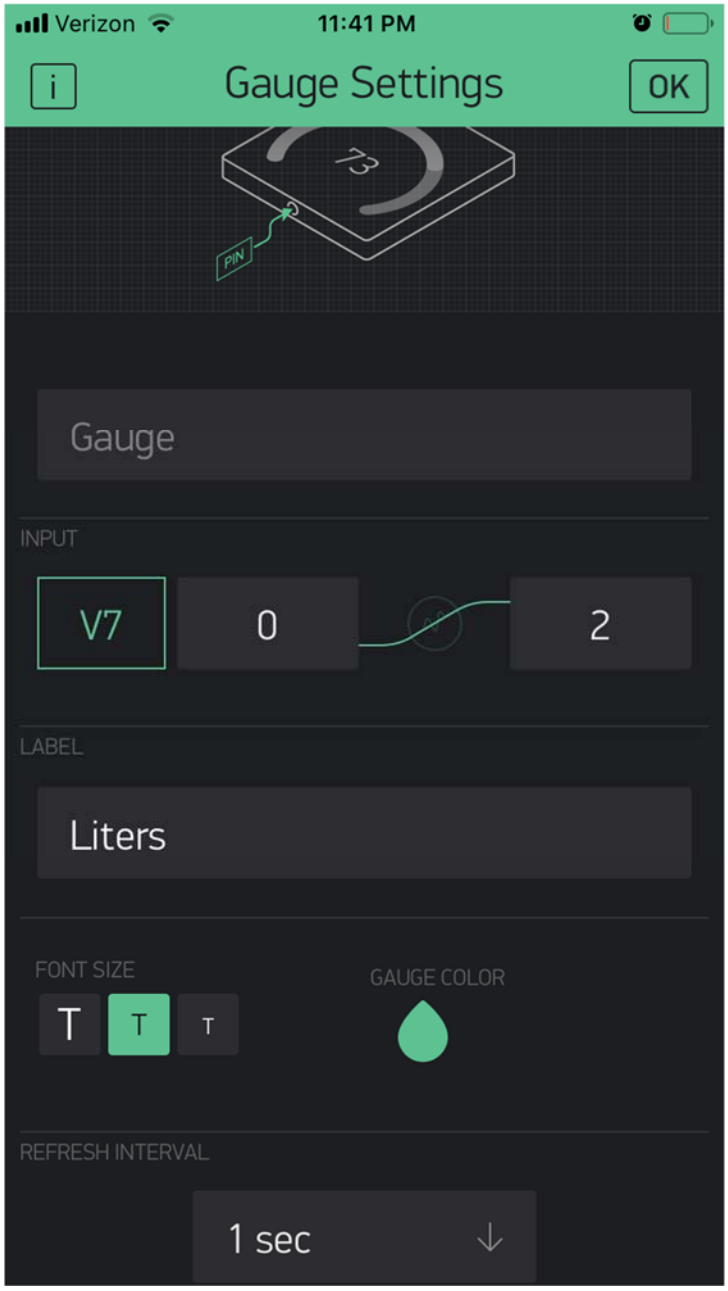
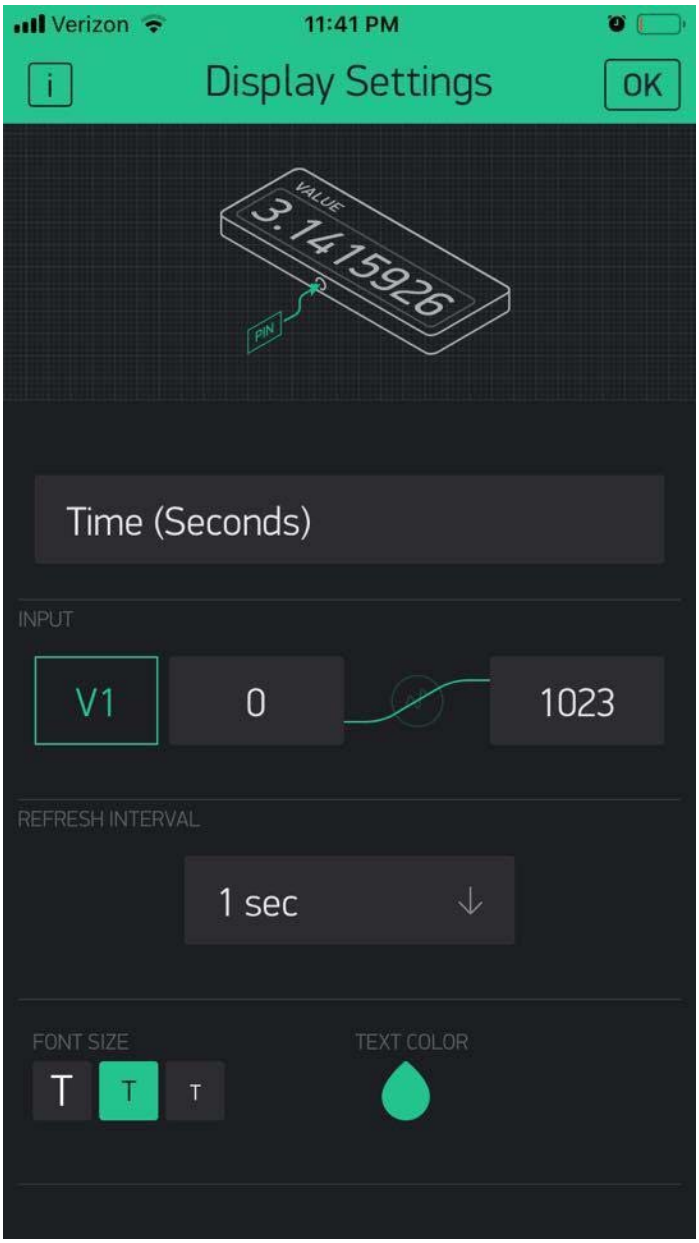
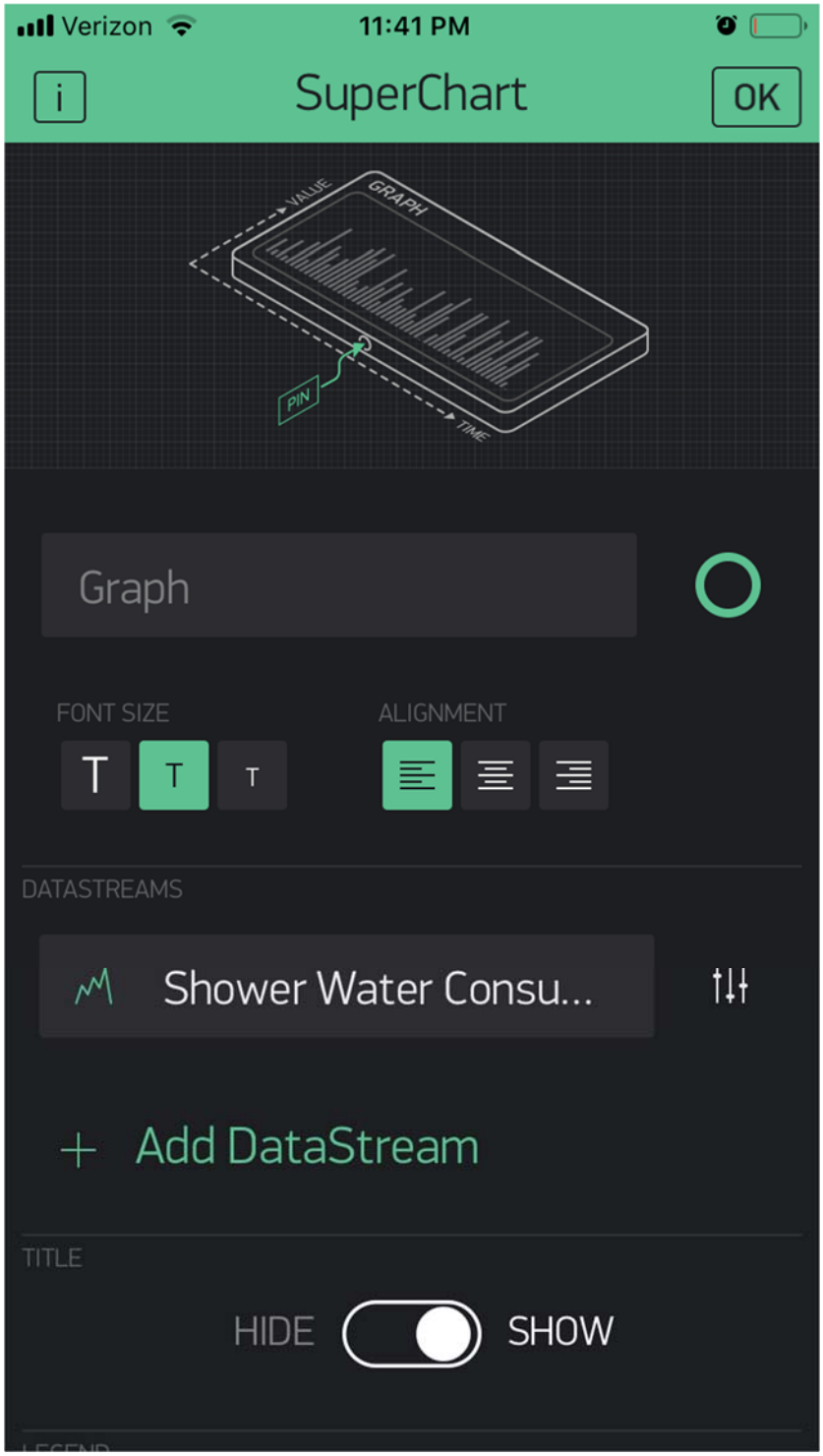
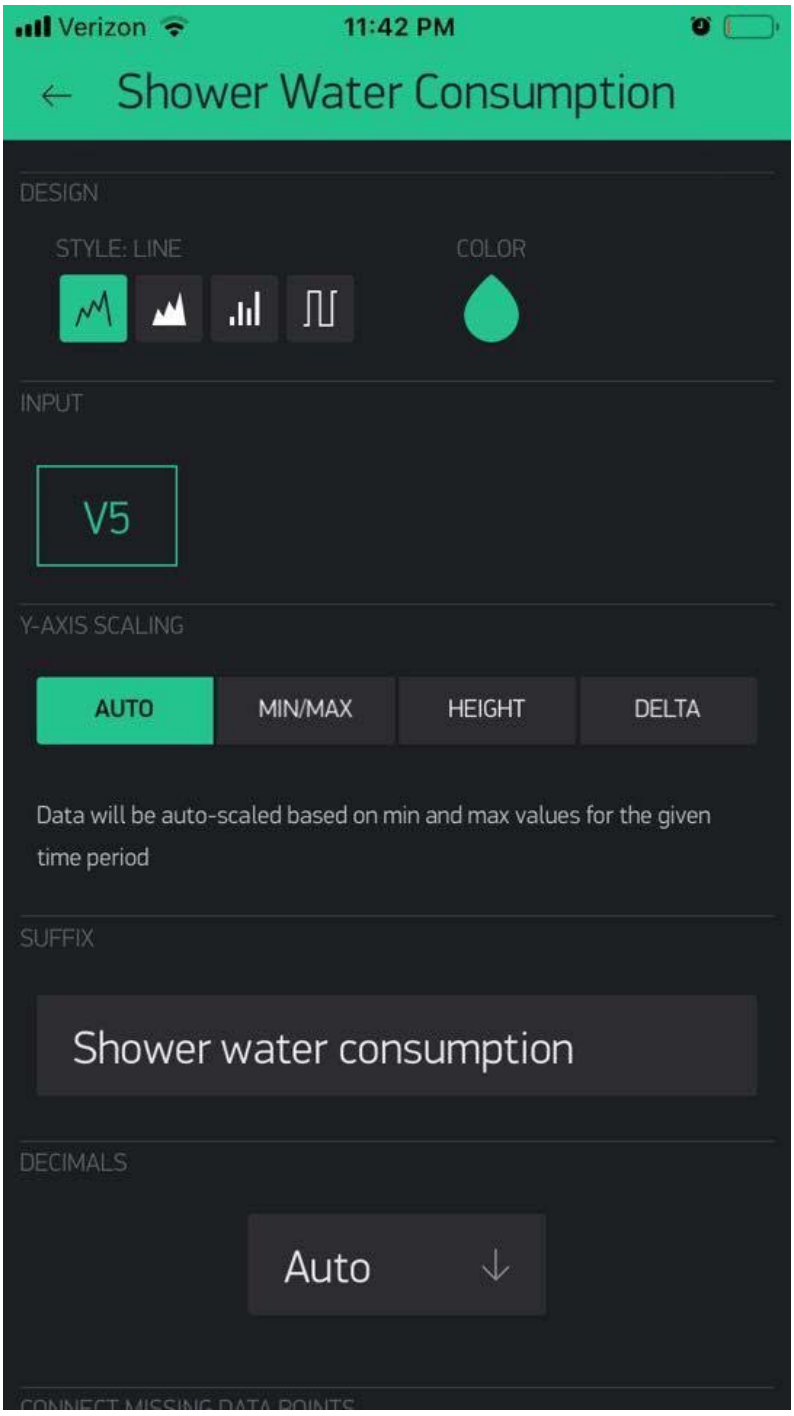


Image3: Shows how the Labeled Display for seconds is configured to read input from virtual pin V1.



Images 4 & 5: Show how the graph widget is configured on pin V5.




Verizon
11:42 PM
Shower Water Consumption
DESIGN
STYLE: LINE
COLOR
INPUT
V5
Y-AXIS SCALING
AUTO
MIN/MAX
HEIGHT
DELTA
Data will be auto-scaled based on min and max values for the given time period
SUFFIX
Shower water consumption
DECIMALS
Auto

Team Aquatech Research Notes Document

This is the price point we initially targeted for with the price breakdown:

Hydroelectric generator : $7
Arduino chip/Equipment : $18
APP: 0
Alarm/vibrator: $1
Led : $5
Cloud storage: based on customer usage
Planned Target Price: $31

Shower Water Meter Planned Features

- Wifi-enabled
- Water Volume measurement
- Hydro electricity-powered
- App - set goals, track data, incentive based
- AI predictions for the year
- Partner with Fairfax Water for generating stats and greater awareness
- Setup thresholds and alert(beeper)

Objective: Design a product that is

- Cheap/Affordable
- Accurate
- Renewable source of energy
- Safe to use in the shower
- Sync up with the wifi/Bluetooth to transmit information to the app
- App with usage reports

We used the following websites/videos to research a few possible parts of our product

Simple vibrating motor:

https://www.adafruit.com/product/1201?gclid=CjwKCAjwusrtBRBmEiwAGBPgE0-twPG3ZWoeFUwc2tJph09lH4ABWIawIYda78TjeWJxQLgdOjcoIBoCrfgQAvD_BwE

https://www.sparkfun.com/products/8449

https://www.youtube.com/watch?v=7ZM09ARDd44

We used the following websites to research information about the app

APP Development:

https://www.globalapptesting.com/blog/developing-apps-internet-of-things-iot

https://ubidots.com/stem/

Research tasks divided by the team:

- How to measure the flow of water/how the water company tracks/how other appliances that track water(researched by Advaith)

A water meter can be simply defined as a tool to measure a consumer's usage of water in a given location. There are three different types of meters; a Mechanical Insert Meter, an Ultrasonic Meter, and an Electromagnetic Meter. Each one of the three meters has its own pros and cons. I believe the best choice for our project would be a mechanical insert meter. This meter would be the best because it is reliable and low cost. The other two options are too expensive for our project. Our aim is to create a cost-effective product and the mechanical insert meter is the best choice for our cause. Below are the pros and cons of these three types of meters.

Mechanical Insert Meter	
Advantages	**Disadvantages**
Reliable and accurate Low cost Efficient mechanism with low maintenance Easy repair or replacement	Requires frequent check for mechanical damage Reliable but not very durable Prone to small particles of rocks or dirt

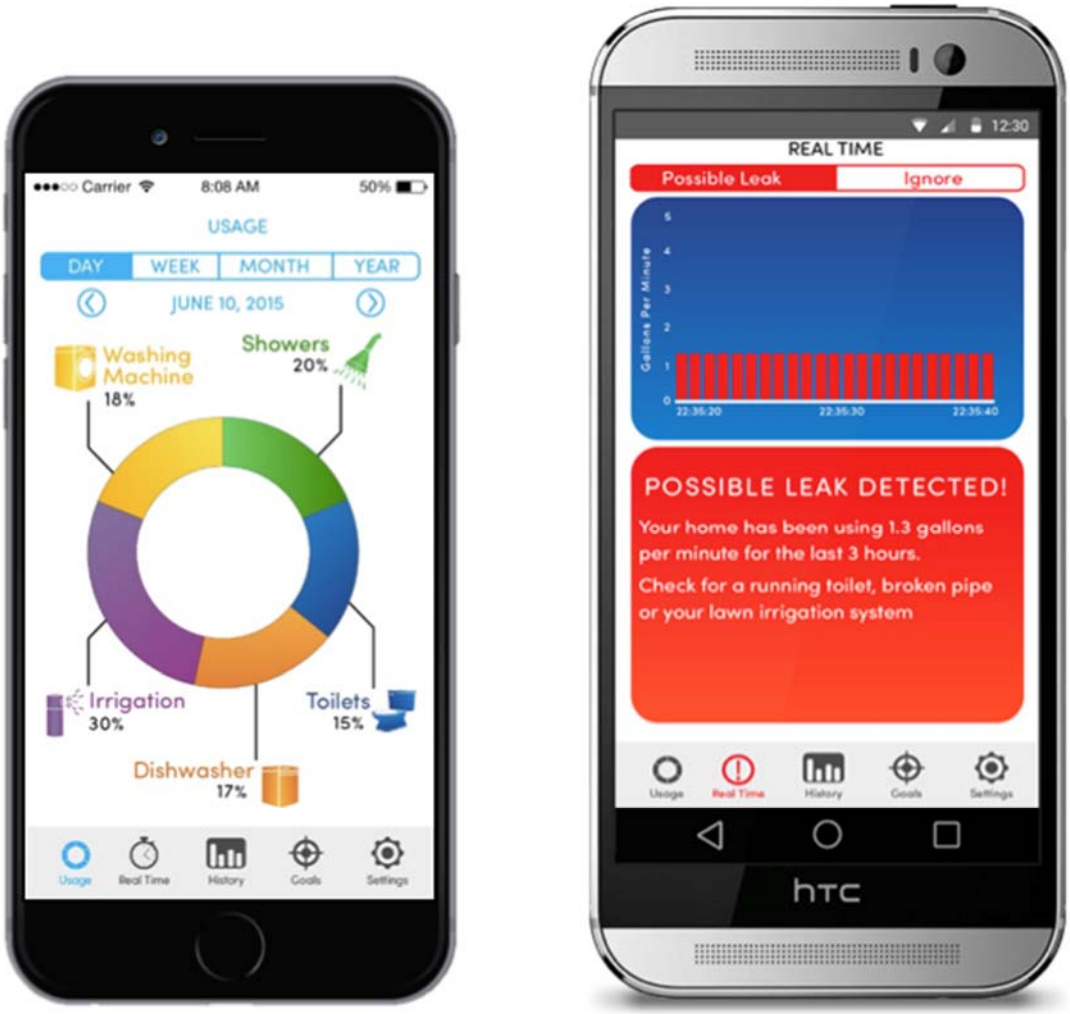
Balkan, David. “How A Water Meter Works Determines Your Water Bill.” *Balkan Plumbing*, 31 Dec. 2019, www.balkanplumbing.com/how-a-water-meter-works-types-reading/.Balkan, David.

Ultrasonic Meter	
Advantages	**Disadvantages**
Simple installation No moving parts Works in all pipe sizes Consistent even at full flow	Requires power supply Difficult to repair

Balkan, David. “How A Water Meter Works Determines Your Water Bill.” *Balkan Plumbing*, 31 Dec. 2019, www.balkanplumbing.com/how-a-water-meter-works-types-reading/.Balkan, David.

Electromagnetic Meter	
Advantages	**Disadvantages**
Very low inaccuracy tolerance (+/- 0.15%) Consistent even at full flow No moving parts Low to none maintenance required	Prone to lightning damage due to electric shock Requires power supply Can be difficult to repair

Balkan, David. “How A Water Meter Works Determines Your Water Bill.” *Balkan Plumbing*, 31 Dec. 2019, www.balkanplumbing.com/how-a-water-meter-works-types-reading/.



Magee, Christine. “FLUID Is A Smart Water Meter For Your Home.” *TechCrunch*, TechCrunch, 15 Sept. 2015, techcrunch.com/2015/09/15/fluid-is-a-smart-water-meter-for-your-home/.

References

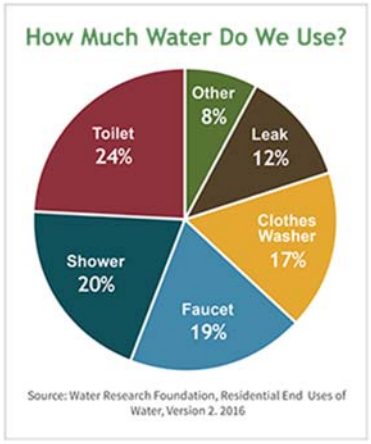
- https://www.hunker.com/13416502/how-does-a-water-meter-work

- https://www.shttps://www.hunker.com/13416502/how-does-a-water-meter-workmarthomewaterguide.org/how-to-read-your-water-meter

- **How to connect the water meter with the wifi transmitter** (**researched by Remi**)
  - Smart bulbs, smart plugs, and other small electronic devices can connect via WiFi to your phone for you to be able to control them, so it is possible to put something that small into a showerhead as well so you could set a timer on your phone and it would turn off or make the showerhead emit an alarm after a set amount of time.
  - Smart plugs can be connected to your phone where you can program them to shut on and off at a set time.
  - With a showerhead, you could build in a light that would indicate to the user that the time is up.
  - There are microchips that support the ability to connect things via WiFi.
  - https://create.arduino.cc/projecthub/jeffpar0721/add-wifi-to-arduino-uno-663b9e (Arduino WiFi chip) - I have an Arduino account that we can log into in order to program the chip.
  - https://store.arduino.cc/usa/arduino-uno-rev3 - Here is the same chip for sale.

- Measure/Research the usage of shower water compared to the total consumption of water (researched by Saranya)

  - Showers make up 17% of the water that is used indoors.
  - Showers are the third largest water use of water in the American home.
  - The average American shower uses about 17 gallons of water and the shower lasts around 8 minutes.
  - The average American family uses about 40 gallons every day.
  - That makes up roughly 1.2 trillion that gets used by the U.S. every year. That's enough water to supply New York and New Jersey for a year!
  - While standard showerheads use 2.5 gallons, showerheads with the WaterSense label demonstrates they don't use more than 2.0 gallons of water.
  - Our water usage in 2016:

- 

"How We Use Water." *EPA*, Environmental Protection Agency, 5 Feb. 2018, www.epa.gov/watersense/how-we-use-water.

- The average family spends over $1,000 per year regarding water.
- WaterSense products (excerpt):
  - "WaterSense labels products that are 20 percent more water-efficient and perform as well as or better than standard models.
  - The average family can save 13,000 gallons of water and $130 in water costs per year by replacing all old, inefficient toilets in their home with WaterSense labeled models.
  - Replacing old, inefficient bathroom faucets and aerators with WaterSense labeled models can save the average family $250 in water and electricity costs over the faucets' lifetime.
  - Replacing showerheads with WaterSense labeled models can reduce the average family's water and electricity costs by $70 and can save the average family more than 2,700 gallons of water per year, equal to the amount of water needed to wash 88 loads of laundry.
  - Giving a home's main bathroom a high-efficiency makeover by installing a WaterSense labeled toilet, showerhead, and faucet aerator can pay for itself in as little as 1 year.
  - Replacing a standard clock timer with a WaterSense labeled irrigation controller can reduce an average home's irrigation water use by 15 percent and can save an average home nearly 7,600 gallons of water annually."

"Statistics and Facts." *EPA*, Environmental Protection Agency, 7 Nov. 2018, www.epa.gov/watersense/statistics-and-facts.

- Research all the similar products in the market (researched by Saranya)

AMAZON:

- Waterproof wall timer with humidity display
- Sand timer with suction cup
- In-wall countdown timer switch

OTHERS:

- Water timer sets the time for 5, 8, or 11 minutes, then cuts the flow to 2/3s when the time is up. It also has an alert tone.
- Professional shower timer

- Research by others in the team

https://www.amazon.com/WaterHawk-Smart-Shower-Temperature-Display/dp/B01C47Q2S0

https://www.amazon.com/Sunsbell-Waterproof-Temperature-Humidity-Bathroom/dp/B07PB8GHV7/ref=sr_1_2?keywords=shower+timer&qid=1568481694&s=hi&sr=1-2.

https://www.amazon.com/Bathing-Sandglass-Management-Bathroom-Accessory/dp/B07JNFSPX3/ref=sr_1_13_sspa?keywords=shower+timer&qid=1568482803&s=hi&sr=1-13-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExRkZUQThQRlpPUVpaJmVuY3J5cHRlZElkPUEwMzcxMjI0MU4xWVBWMk1HTUlTNSZlbmNyeXB0ZWRBZElkPUEwMzA5ODk3M1FJNklaMk1RMUlOSyZ3aWRnZXROYW1lPXNwX210ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU=.

https://www.amazon.com/Enerlites-HET06A-White-1-5-10-15-20-30-Countdown-Decorator/dp/B00IB0ZJXE/ref=sr_1_10?keywords=shower+timer&qid=1568482803&s=hi&sr=1-10.

WEB PAGES USED

Link	***Showers Water Stats Products***
https://www.epa.gov/watersense/showerheads	Information about shower water consumption.
https://www.portlandoregon.gov/water/article/305153	Information about how much water the U.S uses
https://www.epa.gov/watersense/how-we-	How we use water

use-water	
https://www.usgs.gov/mission-areas/water-resources/science/total-water-use	U.S. Geological survey
https://www.epa.gov/watersense/statistics-and-facts	Water usage
https://www.amazon.com/s?k=shower+timer&i=tools&ref=nb_sb_noss_2	Source for finding similar products
https://www.showermanager.com	Shower timer website
http://watersmarttechnology.com/product/showersmart/	Shower timer product

- **Safety concerns for coupling water meter with battery-operated sensor/transmitter- hydroelectricity/powered by light-sun/backup power** (**researched by** Anish and Remi)

Electricity + Water = Bad

How much electricity does a timer use:

It uses less than a volt.

How our timer will be powered:

We can choose the following battery given the size of our timer.

1) CR2032 lithium-ion coin cell(Used in most stopwatches and timers)
    - This battery has 3 Volts
    - Very common in smaller products
    - Lower end prices are around 50 - 75 cents
    - Higher-end(Duracell, etc.) are around 1.75+ each
    - Dimensions: 5.4 x 2 x 0.3 inches
    - Weight is around 3 grams
    - Slightly big
2) LR41 battery lithium-ion coin cell(I found this in a store-bought timer)
    - Are used for small electronic devices that require a very compact power source
    - A device may take multiple LR41 batteries stacked one on top of the other because it increases the voltage and power output.
    - Voltage is generally 1.5 volts
    - The diameter of an LR41 battery is 7.9 mm (5/16")
    - The height from top to bottom is 3.6 mm (9/64")
    - They are safe since it does not contain mercury in case of a leak

- There are 2 types of LR41 batteries, alkaline, and silver oxide, which are both pretty similar. The only difference is that the silver oxide have larger capacities and are better for high drain appliances
- It is commonly known as an AG3 battery
- Incredibly cheap

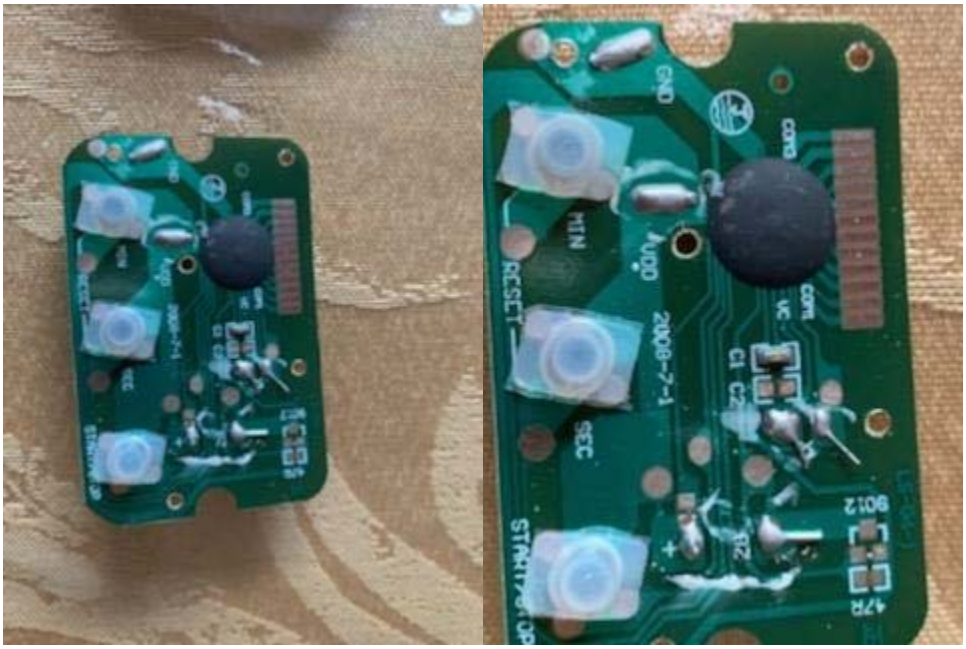
Solar Panel Status:
It is possible to implement solar panels into our timer. Although it may require more work.

To charge a 3V battery, we need a 5V Solar Panel

a) Pros of a Solar panel

- They are around $5-$10 depending on where you get them and the size
- Most of them can hold around 5 or 3 Volts, which would last almost/less a week without a recharge for our timer purposes

What store-bought timers look like. Anish researched the circuits by taking these devices apart:




GND
CORD
MIN
RESET
2008-7-1
SEC
START/STOP
9012
472


ELECTRONIC TIMER
MINUTERIE ÉLECTRONIQUE

The back/inside of the timer runs on a LR41(AG3) battery which is listed above. These circuits look kind of cool. The white things on the circuit board were already there.
I noticed that the part making the sound was an active buzzer.

How we can create the timer circuit:

1) 555 Timer Chip - very common
   Apparently, we can use something called the 555 Timer Chip. You can use the 555 chips for basic timing functions, such as turning a light on for a certain length

of time, or you can use it to create a warning light that flashes on and off. You can use it to produce musical notes of a particular frequency.
--However, this will require at least 4.5 Volts of power, which would use four AA or AAA batteries(1.5V each), or a single 9 V battery.

2) A capacitor may be used with a resistor to produce a timer
This requires 6V of charge and may not be a feasible option

-Batteries -Solar Panels -Circuitry	**Web Pages Referenced**
Prices on Amazon	https://www.amazon.com/s?k=cr2032+3v+lithium+cell+battery&gclid=CjwKCAjwzdLrBRBiEiwAEHrAYml0jrbtPzR5siFnmrnDMO69ID2KnSjwTa_WqSYkiC5a0VopsU99BBoChnAQAvD_BwE&hvadid=177776525676&hvdev=c&hvlocphy=9007576&hvnetw=g&hvpos=1t1&hvqmt=b&hvrand=8314669458525676573&hvtargid=kwd-8382737993&hydadcr=21468_9712400&tag=googhydr-20&ref=pd_sl_317zq6uip9_b
Information on batteries	https://en.wikipedia.org/wiki/Button_cell
Really useful website; talks a lot about batteries and the different types	https://www.batteries.com/pages/coin-cell-button-cell-battery-guide
Prices on Amazon and was used to see different models	https://www.amazon.com/s?k=tiny+solar+panels+projects&i=lawngarden&ref=nb_sb_noss
A part of the 555 timer chip	https://www.dummies.com/programming/electronics/components/electronics-components-how-the-555-timer-chip-works/
Resistor + Capacitor	https://electronics.stackexchange.com/questions/315174/creating-a-timer-in-an-rc-circuit

Below are some useful articles/videos:(by Remi)

REFERENCES
https://www.researchgate.net/publication/311254937_Architectural_framework_of_smart_water_meter_reading_system_in_IoT_environment
https://www.youtube.com/watch?v=sXs7S048eIo

Additional Research Tasks:

1. Advantages/Disadvantages of similar products available in the market (Remi)
2. How to store extra renewable energy and use it (Saranya)
3. Collaborating with companies producing similar products - locally if possible. Get the contact names (Advaith)
4. Research what other features we can add to the product to make it indispensable (Anish)

Saranya- How to store extra renewable energy and use it

- Energy storage captures energy produced to use it later
- Devices that store energy are usually accumulators or batteries
- Energy comes in forms like chemical, nuclear, mechanical, radiant, electrical, and thermal.
- In order to store energy, you need to convert it into a more storable type of energy
- Ways to store energy
    - Lithium-ion batteries
    - ESS batteries
    - You can store it electrochemically using a battery
    - You can store it mechanically with a flywheel
    - With turbines

SOURCES

Energy Storage	**https://en.wikipedia.org/wiki/Energy_storage**
How energy storage works	**https://www.ucsusa.org/clean-energy/how-energy-storage-works**
How to store renewable energy	**https://cen.acs.org/business/investment/Counting-ways-store-renewable-energy/96/i42**

Advantages/Disadvantages of Similar Products Available in the Market - Researched by Remi

Advantages:

- They have already been made; we would just have to make adjustments to the product.
- They are simple and installation seems easy.

Disadvantages:

- They can be expensive.
- They do not all do exactly the things that we want them to do (e.g. measuring and keeping track of the number of gallons of water used in one shower.)
- They might not be 100% accurate - however, I don't think that it is possible to make it 100% accurate.
- We can't buy one of these things and present it as though we were the ones who made it. We would have to take it apart, make adjustments, and add or take away things. This could be difficult and if we were to take it apart and lose a piece or break it in some way, we would have to buy another.

Other features that we can add to the product(Researched by Anish):

-The app which would track statistics, specifically compared individually, family, entire users based, include motivation notes(you may save $x, you are increasing the time it takes for all the freshwater to run out, etc.).
https://www.thegreatapps.com/apps/shower-timer - a shower timer app

https://www.amazon.com/WaterHawk-Smart-Shower-Temperature-Display/dp/B01C47Q2S0 ---<really cool>
But--WARNING: This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.
-Powered by a hydroelectric generator, no batteries uses kinetic energy for power
-Track water usage in gallons per minute
-Tracks temperature
-Display uses LED lights

http://www.brightap.com/ -Also cool
-connects via Bluetooth to app

Advaith research

This is a visualization below

It is….. A “Wall Clock” that we can customize to track the gallons and create an app

Types of Display Screens we can use: I used this

A seven-segment(for the “8”) of the following(They have 28 total segments)

LED

~~VFD - Smaller and Harder to See~~

LCD

LED vs LCD

LED’s are energy efficient diodes and consume less power than LCD. They save power by about 20-30%, so we should use them.

LED boards:

We could have a 32x16 or 32x32 RGB LED Matrix, which is compatible with the Arduino(UNO, mega, zero)

The 32 x 16 should be enough, which is 512 LED’s

The 32 x 32 is 1024 LED’s

-The boards have the red, blue and green color functionality and can combine to get 4096 colors on a 16 MHz Arduino Uno

-If all the LEDs are used, it needs 4 amps. If it is displaying “typical graphics and animation,” these panels will use less than 2 Amps. For our purposes, it may use less than 1.5 Amps

They are like $5

https://www.adafruit.com/product/2601?gclid=Cj0KCQjwr-_tBRCMARIsAN413WSCfsP2yc6HHsa3XEwSjjL-YfgQPNIPdJcZ-ObhGvUwiWUvkqHVV9AaAi3AEALw_wcB

Types of Microchips/Micro-controllers (Researched by Anish, Advaith Remi and Saranya)

Arduino ESP32

-32-bit processor

-Bluetooth:

- Supports Bluetooth 4.2
- Has Bluetooth Low Energy(BLE)

-Has a built in temperature sensor(This would be a really cool addition to the display

-Touch sensor

-Works at temperatures from -40 to 257 degrees Fahrenheit

-About $12 - $16
-Has 36 GPIO's - input/output
https://makeradvisor.com/esp32-vs-esp8266/
Reflection: This model is overall very good for our purposes, and I really liked the temperature sensor.
Some cons and things we need to think about:

a) The ESP32 is leaning towards $15 on the market and it can't be bought from the Arduino store(they are not selling it). We may have to buy clones.
b) It can get hot(113 degrees Fahrenheit sometimes)
c) Bluetooth is hard to add compared to WiFi
d) Has higher power usage than ESP8266 and has high power spikes while using both Bluetooth and WiFi

Another product on the market is the ESP8266- a related project
It seems like people are using the ESP8266 for water trackers
-This model has a lot fewer features, but can be really cheap($5 ish)
-This model is cheap and works with simple DIY projects
-It is slightly older and is more supported in terms of software
The only problem is that this doesn't have Bluetooth, it only has WiFi

Final Reflection: At first I thought that the ESP32 was a good model, and I thought the temperature measurer was a really cool addition. After browsing the web, I found that the ESP32 has a lot of unnecessary features and that the ESP8266 can do the job.
THIS A GOOD PLACE AND PRICE TO BUY IT
When looking at the data, almost 1⁄3 people said it should cost $10-$20, which is actually reasonable if we use this board.

The comparison chart is listed below: This shows the pros and cons of both the ESP8266 and the ESP32 Module

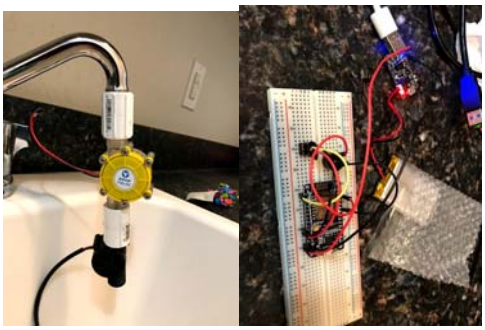
	ESP8266	ESP32
		
MCU	Xtensa Single-core 32-bit L106	Xtensa Dual-Core 32-bit LX6 with 600 DMIPS
802.11 b/g/n Wi-Fi	HT20	HT40
Bluetooth	X	Bluetooth 4.2 and BLE
Typical Frequency	80 MHz	160 MHz
SRAM	X	✓
Flash	X	✓
GPIO	17	36
Hardware /Software PWM	None / 8 channels	None / 16 channels
SPI/I2C/I2S/UART	2/1/2/2	4/2/2/2
ADC	10-bit	12-bit
CAN	X	✓
Ethernet MAC Interface	X	✓
Touch Sensor	X	✓
Temperature Sensor	X	✓
Hall effect sensor	X	✓
Working Temperature	-40°C to 125°C	-40°C to 125°C
Price	$ (3$ - $6)	~~$8 ($6 - $10)~~ $12 - $16
Where to buy	Best ESP8266 Wi-Fi Development Boards	ESP32 Development Boards Review and Comparison

kits/

Santos, Sara, et al. “ESP32 Vs ESP8266 - Pros and Cons.” *Maker Advisor*, 6 May 2019, makeradvisor.com/esp32-vs-esp8266/.

How will you test your solution? The BEST way to test your solution is to build a working model or a prototype that you can actually use. Or you can guess how your solution will work BASED ON your research. Which method will you use and why?

We decided to test our solution by building a working prototype because this method would provide us with hands on experience with designing and building a real product. Our project was based on an Arduino ESP8266. We had fun playing and experimenting with the code to get our product to work. Our prototype consisted of a 5 volt hydro-electric generator, a flow sensor with a hall effect sensor, an arduino ESP8266 with built in WiFi, an active buzzer, and a powerboost 1000c. If we didn't build a prototype we wouldn't have learned by hands on experience dealing with "random error problems", such as having loose connections or the generator not generating enough electricity to power the whole device. Also, we would not have been comfortable and satisfied with predicting how our solution would work or react solely based on research.



As mentioned above, the best way to test any solution is to build the prototype. We needed to make sure the various components in the prototype were performing the assigned task correctly.

Here is the list of components we used:

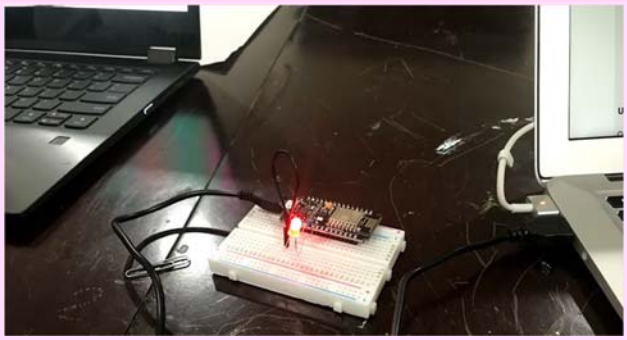
1. ESP8266 NodeMCU
2. Arduino Active Buzzer
3. Hydroelectricity Generator (https://www.amazon.com/Hyuduo-Regulated-Hydroelectric-Generator-Micro-Hydro/dp/B07XC2K2MP/ref=sr_1_8?keywords=hydro+electricity+generator+5v&qid=1582597334&sr=8-8)
4. Water Flow meter with Hall effect sensor (https://www.amazon.com/DIGITEN-Sensor-Switch-Flowmeter-Counter/dp/B00VKATCRQ/ref=sr_1_13?keywords=water+flow+sensor&qid=1582597275&sr=8-13)
5. Adafruit PowerBoost 1000c
6. Lithium Ion Polymer Battery 3.7v 1200mAh
7. Blynk App

We tested every phase of the solution to make sure it is working correctly and as expected. After we integrated all the components, we tested the system to see if the desired outcome of alerting users when the threshold is met was achieved.

Here is the list of tests:

Active Buzzer:

1. Test the Active Buzzer is firing when the threshold is met.
2. Test Active Buzzer stops after the water flow stops.



These photos are from the meeting where we learned to activate the buzzer and connect it to the Blynk app, shown on the phone in the rightmost picture.

Hall Effect Sensor:

1. Test how many rotations are generated to output 1Liter of water (which we found out to be 200).
2. Test the number of Liters that are being counted matches with the number of liters collected in the water container.
3. Test the number of rotations stops when the water stops.

Blynk App:

1. Test the gauge that displays the number of liters used is accurate.
2. Test the gauge that displays the number of seconds that the water has been running is accurate.
3. Test the Liters Line graph is updating when shower is in use and shows information for the time period correctly.
4. Test the number Labels are showing the information correctly.

Other Components:

1. Test the rechargeable battery is able to power the Nodemcu before/after hydroelectricity starts/stops.
2. Test the LiPo battery is getting charged when the hydroelectricity is being generated

We performed multiple tests to ensure the results are consistent, accurate, and repeatable.

If you built a prototype or model, explain how you built your prototype or model, step-by-step including ALL SAFETY PRECAUTIONS. If you guessed how your solution would work BASED ON your research, explain important information from your research that you used to prove how your solution would work and be sure to cite your sources.

We took several steps to create our smart shower tracker, and have also learned a lot through the process. Some of the iterations of our model include:

1. Arduino programming with IDE
2. Connecting breadboard with different components
3. Building/planning the design
4. The app development

Although all aspects of the project are important, one of the most time consuming aspects was the construction of the device. Since we were new to circuits and programming with Arduino, we spent a lot of time familiarizing ourselves with the components, but it was time well spent since we learned so much in the process.

Part of this learning experience started with multiple “mini projects,” so we could start simple, and work towards tackling the more complicated tasks as we learn.

1. Our first project was a LED project, which we connected to an app where we could turn the LED on or off. Although this was a very small project, we learned how to use resistors, jumper wires, and got a basic foundation. We made sure to remove food/drink from the area to limit the possibility of it coming in contact with the Arduino.
2. Having the satisfaction that it worked, we decided to write a code to activate/deactivate an active buzzer. The buzzer was one small part of our model.
3. We progressed to the hall effect sensor. Although we faced a few issues, like an unstable connection between the laptop and the Arduino, we eventually were able to read data from the serial plotter/monitor. We didn’t want to take the risk of water, so we decided to stimulate moving water by blowing into one of the openings of the Flow Meter. This way, we were also able to conserve water in the earlier phases.
4. One of the hardest parts from the programming perspective was combining the code, and adding conditional statements to satisfy our needs. One repetitive part of this was continually testing, tweaking and redownloading the code to fix an error, and make it functional.
5. From the building standpoint, we had to come up with a design to attach the hall effect sensor and the generator to the showerhead. We also received assistance from an adult while soldering loose connections, and made sure to wear goggles and protective gloves. We also made sure to buy the lead free solder wire, so we could avoid any contact with lead.
6. Next, we connected the electricity generator and the 3.7V LiPo battery to the Adafruit powerboost 1000C as our power source. We know that LiPo batteries can be very dangerous, so we handled them with care as a precaution.
7. Lastly, the device we developed transmits data to an app. Since we were also new to the Blynk software, we learned how to add gauges, graphs, and reference virtual pins to send the data.
8. The final model of our device combined all the parts together, so that they work in unison. For example, the buzzer activated after passing a certain threshold, the data(Time & Liters) synced to the app while the water was running, the Powerboost 1000C(3.7V LiPo Battery &

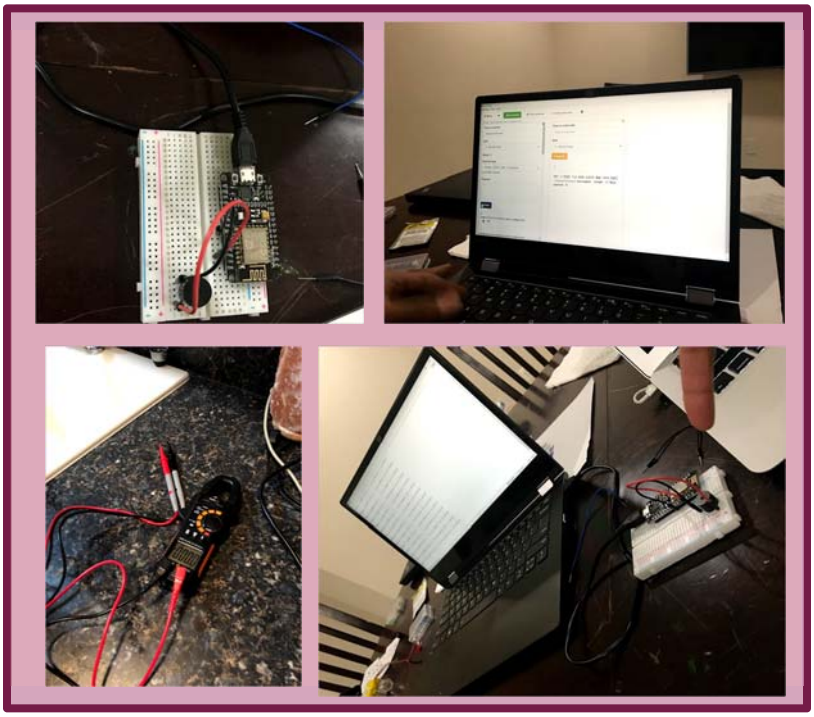
Hydroelectric Generator) was providing a constant supply of power to the Arduino, and the program was successful in telling the Arduino what to do.

Supplies that we used in the final model of our device:

Parts	Link
ESP8266 NodeMCU	https://www.amazon.com/HiLetgo-Internet-Development-Wireless-Micropython/dp/B010O1G1ES
Active Buzzer - Came with the kit	https://www.amazon.com/REXQualis-Electronics-tie-Points-Breadboard-Potentiometer/dp/B073ZC68QG/ref=asc_df_B073ZC68QG/?tag=hyprod-20&linkCode=df0&hvadid=309751315916&hvpos=&hvnetw=g&hvrand=365388456702561954&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9007576&hvtargid=pla-568385709090&psc=1&tag=&ref=&adgrpid=67183599252&hvpone=&hvptwo=&hvadid=309751315916&hvpos=&hvnetw=g&hvrand=365388456702561954&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9007576&hvtargid=pla-568385709090
Jumper Wires - Came with the kit	https://www.amazon.com/REXQualis-Electronics-tie-Points-Breadboard-Potentiometer/dp/B073ZC68QG/ref=asc_df_B073ZC68QG/?tag=hyprod-20&linkCode=df0&hvadid=309751315916&hvpos=&hvnetw=g&hvrand=365388456702561954&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9007576&hvtargid=pla-568385709090&psc=1&tag=&ref=&adgrpid=67183599252&hvpone=&hvptwo=&hvadid=309751315916&hvpos=&hvnetw=g&hvrand=365388456702561954&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9007576&hvtargid=pla-568385709090
Soldering Iron - Came for free as a promotion in the kit	https://www.amazon.com/REXQualis-Electronics-tie-Points-Breadboard-Potentiometer/dp/B073ZC68QG/ref=asc_df_B073ZC68QG/?tag=hyprod-20&linkCode=df0&hvadid=309751315916&hvpos=&hvnetw=g&hvrand=365388456702561954&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9007576&hvtargid=pla-

	568385709090&psc=1&tag=&ref=&adgrpid=67183599252&hvpone=&hvptwo=&hvadid=309751315916&hvpos=&hvnetw=g&hvrand=365388456702561954&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9007576&hvtargid=pla-568385709090
Hydroelectricity Generator	https://www.amazon.com/Hyuduo-Regulated-Hydroelectric-Generator-Micro-Hydro/dp/B07XC2K2MP/ref=sr_1_8?keywords=hydro+electricity+generator+5v&qid=1582597334&sr=8-8
Water Flow meter with Hall effect sensor	https://www.amazon.com/DIGITEN-Sensor-Switch-Flowmeter-Counter/dp/B00VKATCRQ/ref=sr_1_13?keywords=water+flow+sensor&qid=1582597275&sr=8-13
Adafruit PowerBoost 1000c	https://www.microcenter.com/product/474415/adafruit-industries-powerboost-1000-charger---rechargeable-5v-lipo-usb-boost-@-1a
Lithium Ion Polymer Battery 3.7v 1200mAh	https://www.microcenter.com/product/503621/adafruit-industries-lithium-ion-battery---37v-2000mah
Lead Free Solder Wire	https://www.microcenter.com/product/442754/aven-solder-100g-12mm-lead-free

The picture below, describes the steps involved in one phase of the project, when the active buzzer was incorporated. There is a code change, we tested the circuit, and checked the program output in Serial Monitor.



What problems did you find with your solution? Be specific since you will need to redesign based on these problems.

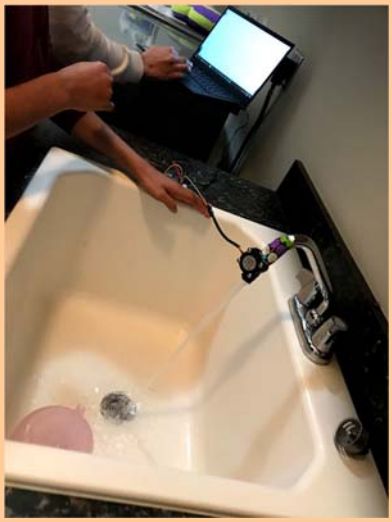
- When using a Macbook Air the port for the ESP8266 wasn't displaying on the Arduino IDE. However, we were still able to use the Mac as a power support. For this reason we had to use Windows machines to program our Arduino.
- Initially, we didn't understand how to connect the 2-pin JST connector to the breadboard.
- When testing our product we were losing data at the beginning. This was because it took the hydroelectric generator a few seconds to start supplying the ESP8266 with the electricity. We solved this problem by using a powerboost 1000c and a 3.7 volt LiPo battery. We connected both the generator and the battery to the bower boost and connected the Powerboost to the ESP8266.
- Sometimes our program wouldn't run properly or it would stop in the middle of testing. We discovered that this was due to the loose connections in our circuit. We solved this by soldering the main loose connections and by taping some of the wires together. An example of this was with our buzzer. The buzzer wouldn't start after reaching the threshold. We later found out that this was because of the loose connections.
- The cords were too loose during testing so we got a few extra jumper wires and taped them together. This served as an extension cord that kept the circuit dry by keeping the device away from the water source.
- The app we were using to display our data (Blynk), sometimes wouldn't display the information and would sometimes disconnect and go offline. We were able to give a temporary solution to this problem by changing the way the data was updated from "push" mode to 5 second interval, which made it more accurate.
- Another problem we encountered was that sometimes the hydroelectric generator would generate less than 5 volts. We were able to solve this problem by using the powerboost 1000c and a 3.7 volt lipo battery.
- We also noticed that when electronic devices were placed close to this device due to electromagnetic interference, the App would not get refreshed. As soon as we moved the device away from electromagnetic interference, we saw consistent results in the App. It took us some time to identify this issue.

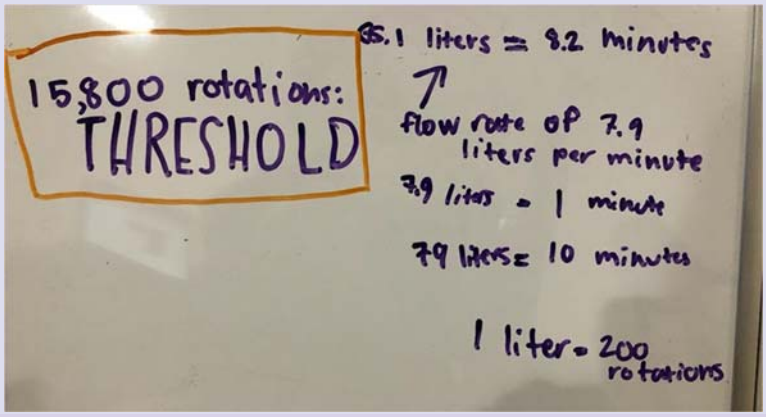
Experiment One:
In order to figure out how much volts our hydroelectricity generator could generate, we conducted an experiment. We hooked up the generator to a sink faucet, attached it to a voltage tester, which measured 5 volts.

Experiment Two:
In order to find out how many rotations a liter was, we hooked up the generator to the sink again and connected it to our computer, which recorded how many rotations happened. We started the water so it poured into a liter jug, and when one liter was reached, we saw that it took 79 rotations for a liter.

Experiment One:

Experiment Two:





Our results from Experiment #2. After finding out one liter was 200 rotations, we did some equations to end up with 15,800 rotations for our ten minute threshold.

Describe all of the changes you made to your prototype or model (or proposed prototype) after your first test. Why will these changes improve your solution?

At first, we did several different projects to test each individual aspect of our program. Our two main basic programs were a led program and an active buzzer program. In our LED program, we experimented with an app called Blynk. Using an authorization code we connected the Arduino to the app. In the app, we added a button widget. When the button was pressed,the LED would turn on. In the circuit, we had an LED, a few jumper wires, and a 100-ohm resistor.

Our next project was a basic project involving an active buzzer. For this experiment, we used a software called MQTT box. In the software, if we sent a 1, then the buzzer would turn on. If we sent a 0 the buzzer would turn off.

Next, we worked on combining these two projects and started working toward our final project.

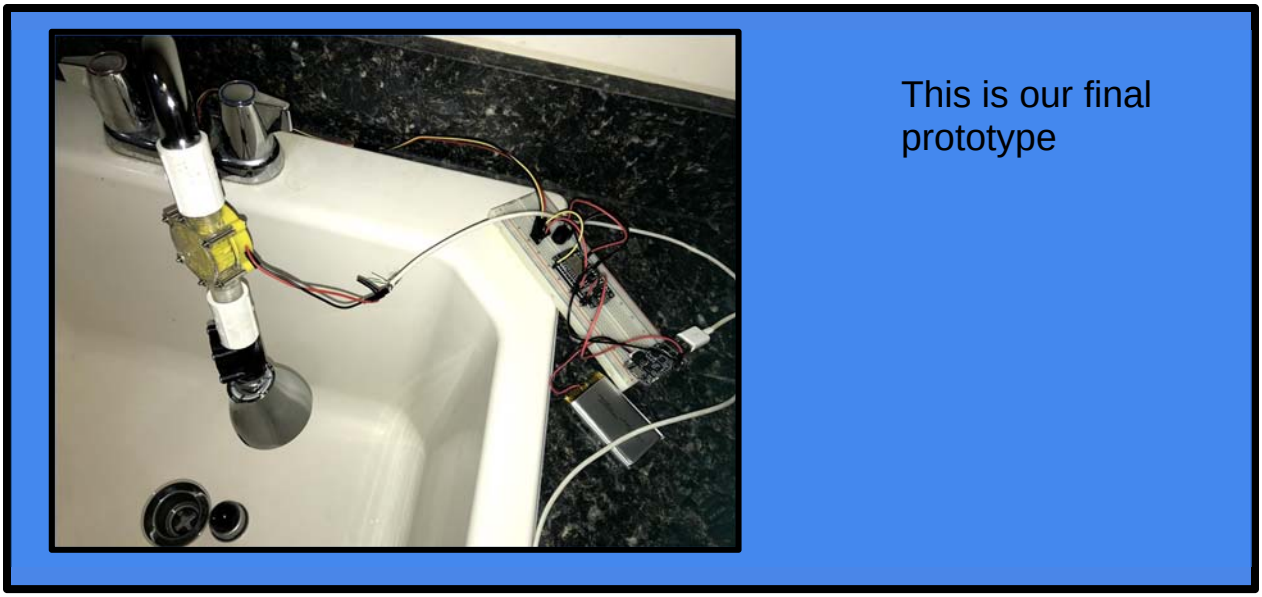
Once we successfully combined the two projects, we worked on setting up a threshold for when the active buzzer would turn on. For example, after the flow sensor reaches a certain number of rotations the buzzer should turn on.

For our physical prototype, we used a hall-effect sensor, a hydroelectric generator, and a few connectors.

In our original model, we connected both the sensors to the esp8266. We later discovered that it was easier to connect the hall effect sensor to the esp8266 and connect the hydroelectric generator to a Powerboost 1000c.

We also connected a 3.7-volt LiPo battery to the Powerboost. We then connected the Powerboost to the Arduino esp8266. The reason we needed the LiPo battery was that it took a few seconds for the generator to power up. In these few seconds, we were losing data. The generator was generating a little of 5 volts. Our LiPo battery has about 2000 hours of lifetime. This is without considering that the hydroelectric generator is recharging the Lipo battery.

We discovered that the hall effect sensor would send a value of 1024. Using the count command, we were able to count the number of rotations. We also knew that 200 rotations were a liter. Using this conversion we could set a number of rotations as a threshold. We set the threshold based on a certain number of rotations to activate and sound the buzzer.



There were some more changes made after integrating with the Blynk app. We noticed that the gauge that displays the time in seconds was updating even when the water was turned off. For this, we had to tweak the program to identify when the water was turned off by comparing the current rotations to the previous rotations and if there is no difference then it means the water has stopped.

We also used this similar logic to turn off the active buzzer as soon as the water was turned off.

In the Blynk APP, we initially only had Gauge widgets, but we wanted to see the Liters and seconds number value so we added Label widgets. We also added a graph widget to capture the history of water usage in a line graph.

To fix the loose contact in wires that was giving us inconsistent results, we soldered the power/Ground wires attached to the power boost.

Another innovative design change was to replace the 2 pin JST connector attached to the hydroelectricity generator with the USB A connector since the powerboost had a USB receptacle and this also helped secure the connection.

Present the data you collected from your tests or from your research. If you tested a prototype or model then include all of the numbers you gathered during your testing and all observations you made. The use of graphs and charts is HIGHLY encouraged. If you used research to prove how your solution would work, be sure to include all of the numbers, charts, and graphs you used to make your case. Be sure that all data is related to your solution.

Here is the data collected from our testing:

Hall Effect sensor pulse reading images are shown below. The highs and lows are generated when the magnet moves close to and away from the sensor. So basically one pulse in the wave corresponds to a rotation. We had to analyze this closely to understand how to calculate a rotation from the variations in the signals.

Image1: Shows the signal when the faucet was just started

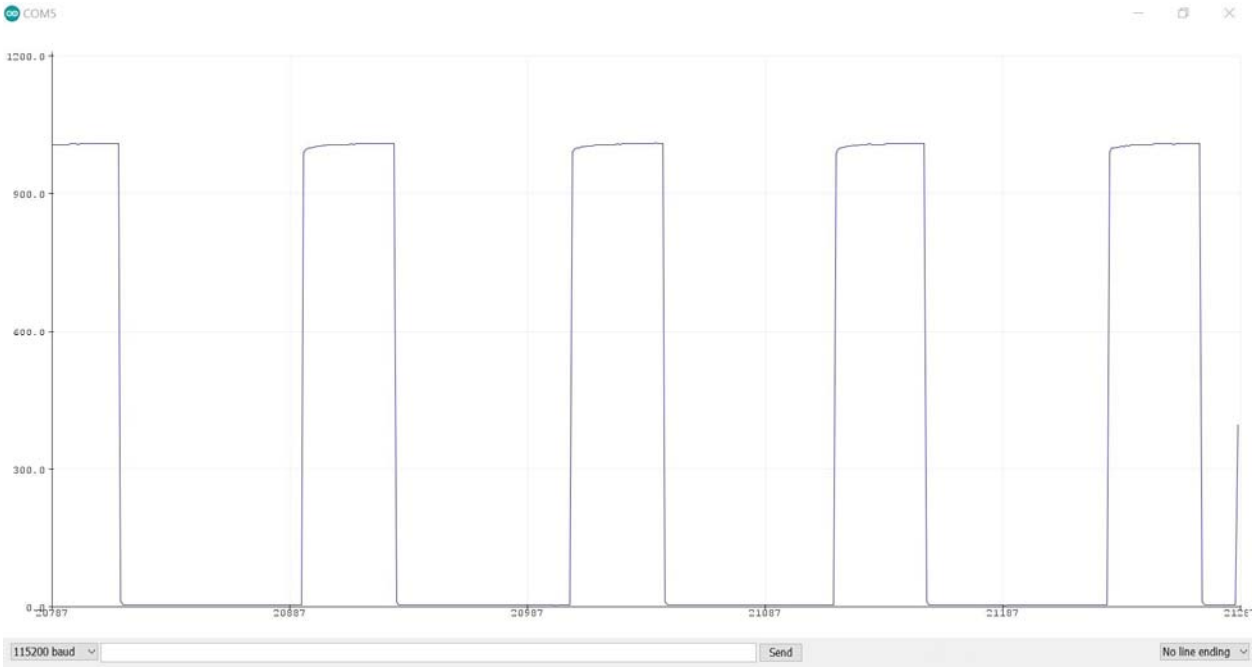


Image2: Shows the transition to high water flow when the rotations have significantly increased

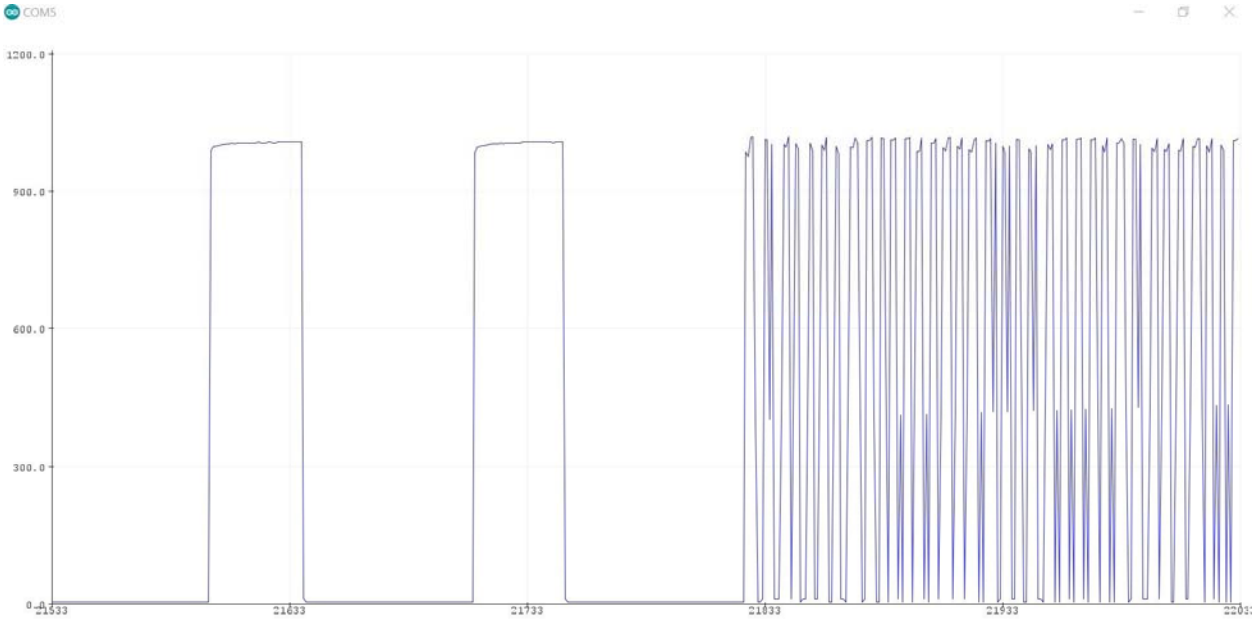
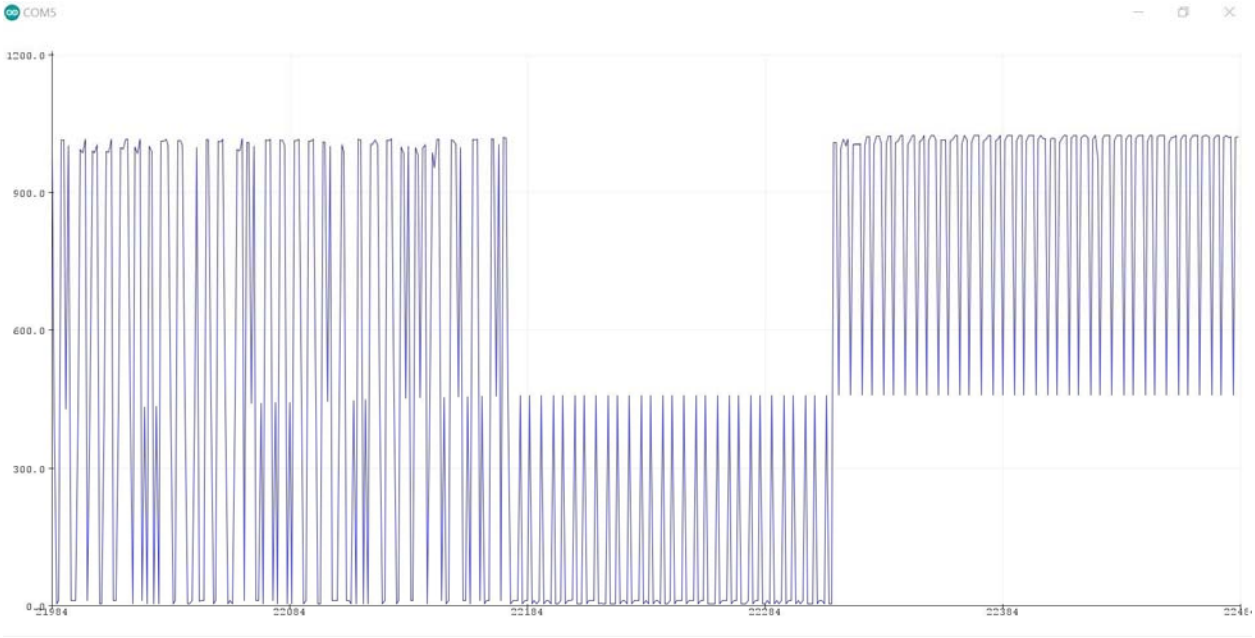


Image3: Show the signal when the faucet just got turned off



Here is how we trouble-shooted the program (C language) in the Arduino IDE using Serial Monitor to check the output by printing variables.

Here are the images from the Blynk APP in sequence where you can see the increase in liters of water over time with the change tracked in a line graph. The images also display a gauge with a threshold of 2 liters being met.

Image 1: Shows App at 4L water usage, after 2L(400 rotation) threshold has been met.

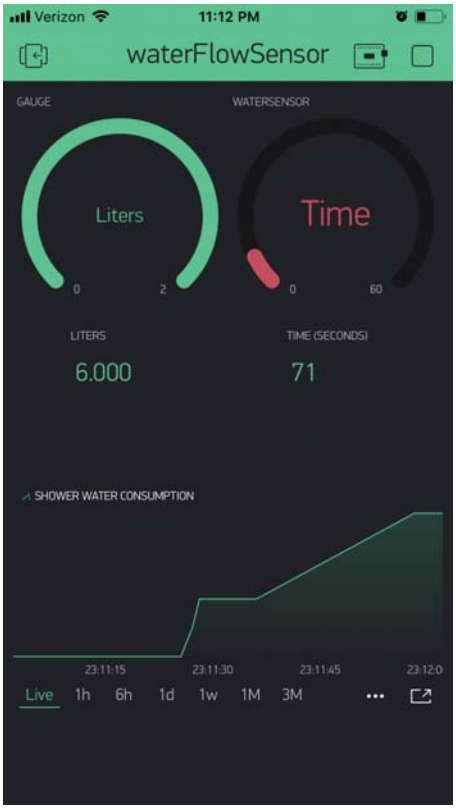


Image 2: Shows App at 6L water usage, water still continues to flow.

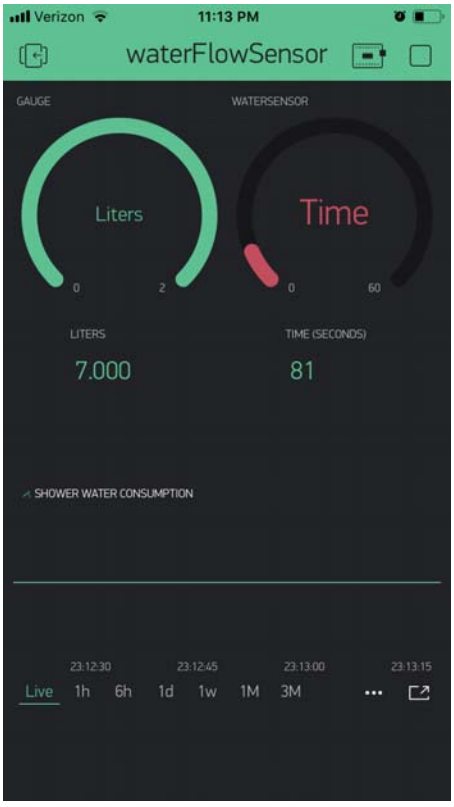
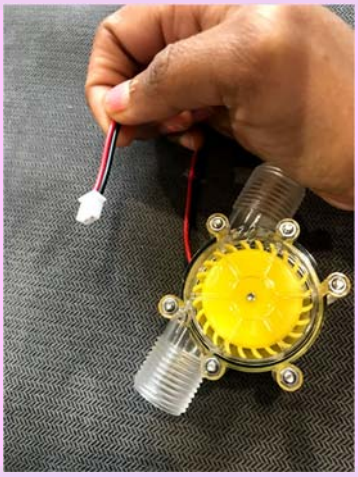


Image 3: Shows App at 7L water usage, after the water was turned off, you can see that the graph is flat.

What are your potential sources of error? Remember, this doesn't mean "Did everything work?", all tests have potential sources of error, so make sure you understand what that means. Explain how these sources of error could have affected your results.

Systematic Errors, according to the eCybermission website, are errors that cannot be corrected through repeated testing. A Systematic Error that we experienced was when we were not measuring the volume of water correctly. Therefore, after repeated inconsistent results, we found that we had introduced a 5 second delay in the program after the buzzer started and during this time the rotations were miscounted which in turn caused incorrect volume calculations.

In another case, we discovered that the JST connector pin of the hydroelectricity generator, when connected to one of the power modules, was consistently delivering less than 5V to the circuit. Somehow voltage was being lost. So we changed the connector to a USB connector with soldering help from an adult and when we connected this to the Adafruit powerboost, there was no voltage lost and it was able to power the circuit reliably along with the battery backup.



A photo of the hydroelectricity generator we used, (it generates roughly 5 volts, as discovered in an experiment). This was the first part we started with.

Another Systematic Error that occured during our project was an issue with the Blynk app. On occasion, we found that it did not refresh correctly due to power fluctuations in the device. While coding the device, we needed to find a way to stop the buzzer after a certain period of time. Initially, we set a delay in the code which effectively turned the buzzer off for a set amount of time before turning it back on again. However, we removed this feature because the delay caused the device to stop counting the rotations of the hydroelectric generator. If the device does not count the rotations, even through the delay, we would lose valuable data regarding the amount of water being used. Sometimes, the wires in the device would have a weak connection, becoming loose and disconnecting. We fixed this by soldering the wires and creating a more stable connection. We were also concerned about how certain water settings did not produce enough pressure to properly power the circuits. To fix this, we connected a LiPo battery to the device to add an additional source of power.

Random Errors are errors that occur when the data has an outlier that is significantly different from the rest of the data. They can be corrected through repeated testing. A Random Error

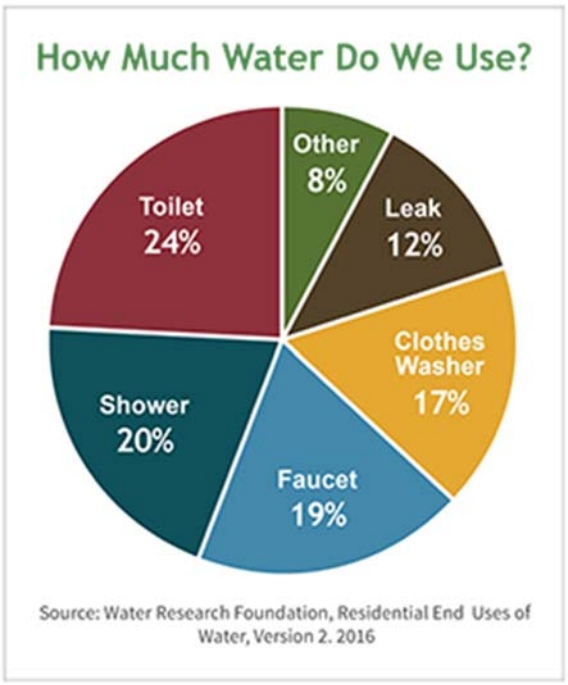
that occurred during our testing was our buzzer sometimes not sounding after reaching the threshold. We found out that this was because of loose connections. We were able to solve this by tightening our connections and by soldering the main connections, while taking safety precautions.

Another random error that took us a long time to identify related to electromagnetic interference. We noticed that when we placed our Laptop close to the circuit, it caused the Blynk App to not refresh consistently. This is in turn, could be due to the variation in the magnetic field that caused the Hall Effect Sensor to not generate the right signal. As soon as we moved the Laptop away from the circuit, we could see consistent refreshes in the Blynk App.

Explain how investigating the problem your team chose will help the community. Be sure to include the impacts your research will have on individuals, businesses, organizations, and the environment in your community (if any). Make it very clear why solving this problem would help your community.

The impact on the community:

Water conservation is a principle that becomes more and more crucial by day. We aim to make a product that will help families cut down their shower water usage, by being aware of their water usage patterns. Showers make up 17% of the water used indoors, making showers the third largest use of water in the American home. The average American family uses 40 gallons per day, contributing to roughly 1.2 gallons that the U.S. uses each year. That is enough water to supply both New York and New Jersey for a whole year! This chart below demonstrates how water usage in the American home was split in 2016.



Therefore, since the shower has a significant impact on water usage, we can make a big impact with our product since it will regulate shower water usage.

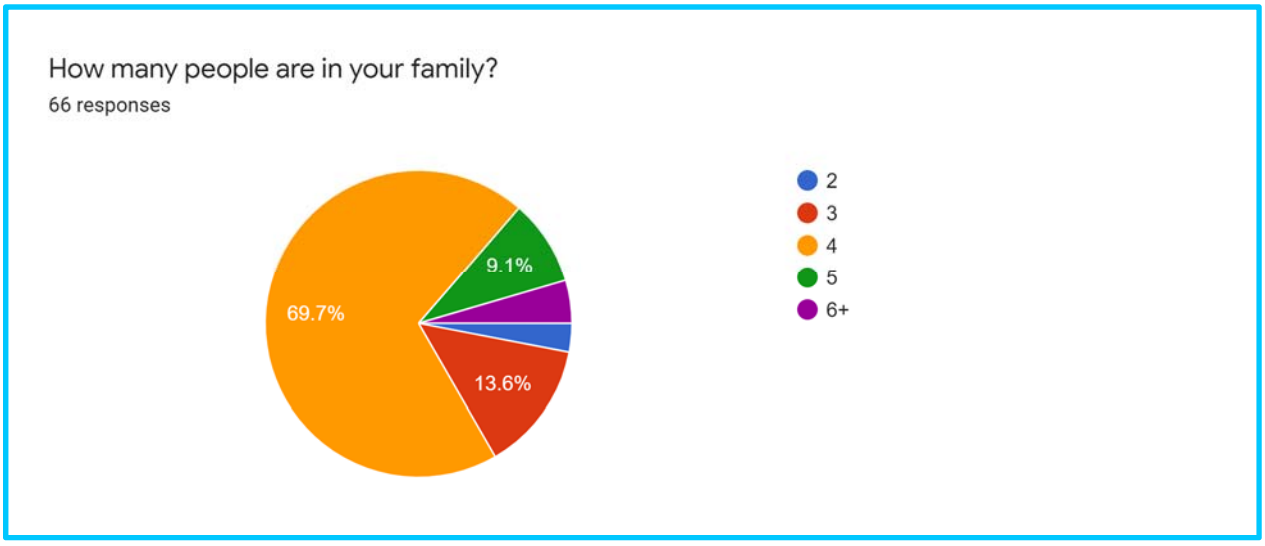
Where the community currently stands

In order to assess the opinions of families including how long they shower and if they are willing to take shorter showers, we each created surveys with the following questions to gain an understanding:

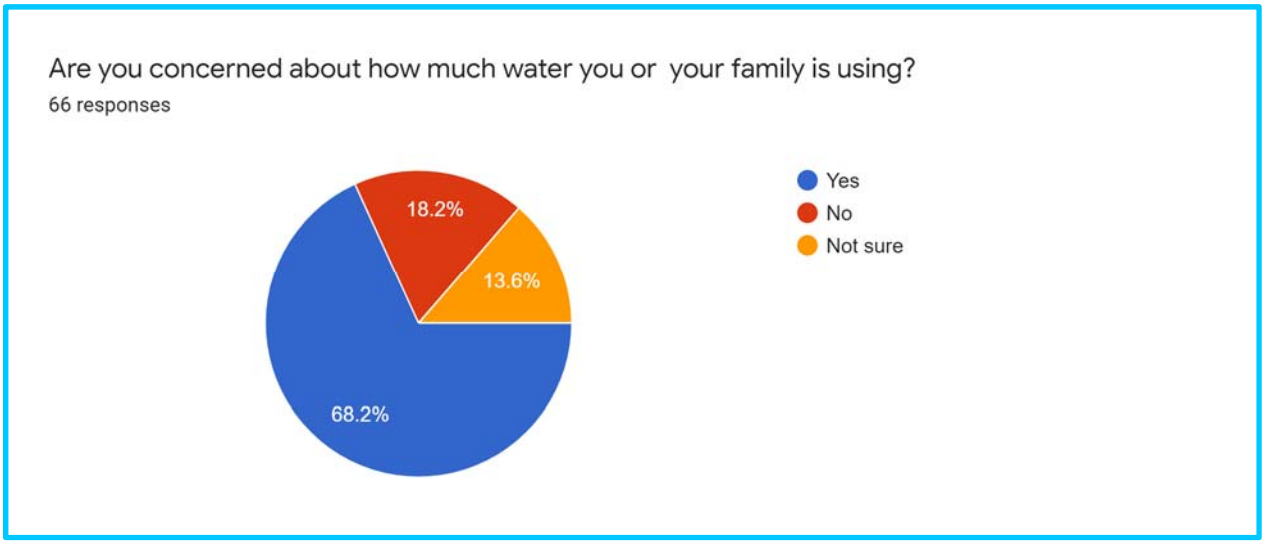
1. How many people are in your family?
2. Are you concerned about how much water you or your family is using?
3. How many showers are in your house?
4. How many times a day do you shower?

5. How much time do you spend in the shower in a single-use?
6. What do you think is the right time to spend in the shower?
7. Would you be willing to cut down your shower water usage to conserve water?
8. Would you like to track your shower water usage?
9. Do you already own a shower water tracker?
    a. If you have a shower water tracker, how much does it cost?
10. How much are you willing to pay for a smart shower water sensor?

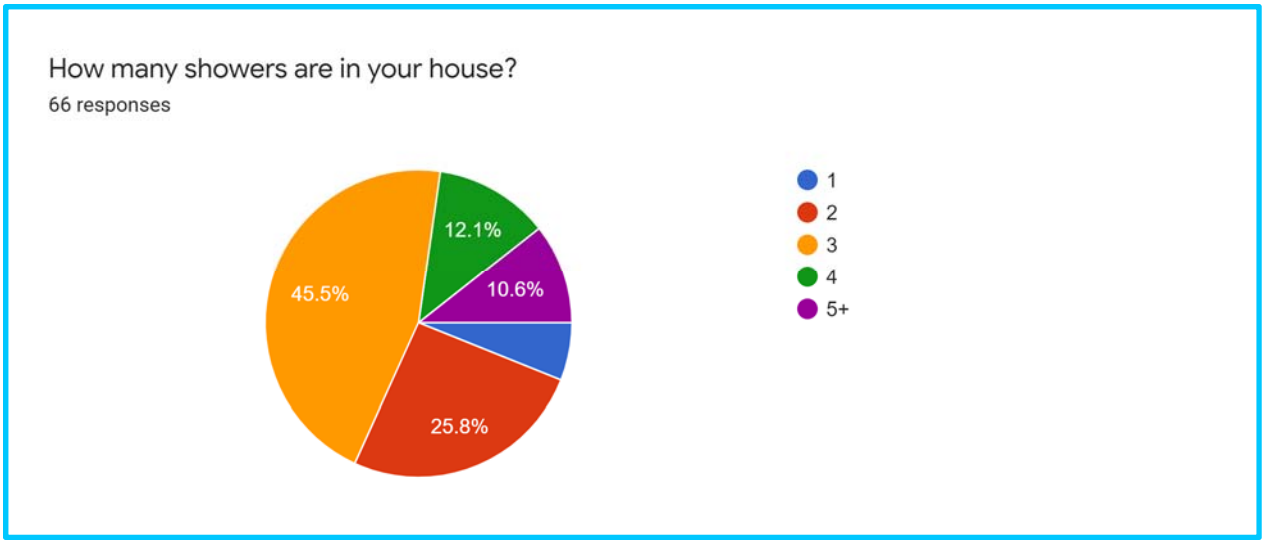
Here are some results from Saranya's survey (which had 66 responses)



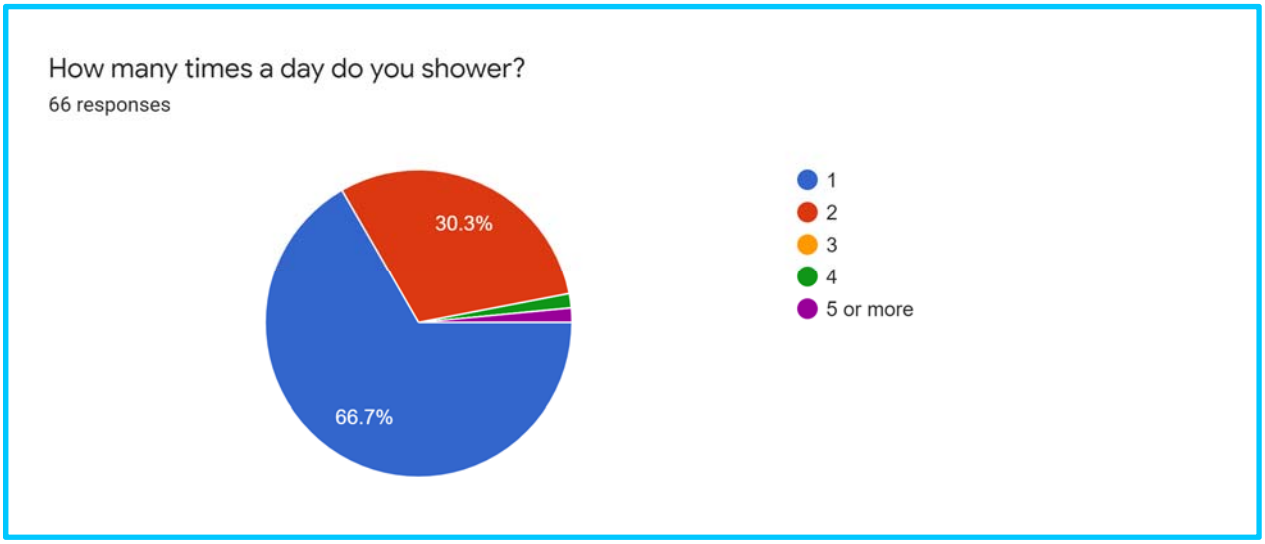
Most families have 4 people using the shower, then 3, then 5, then more than 6, then 2.



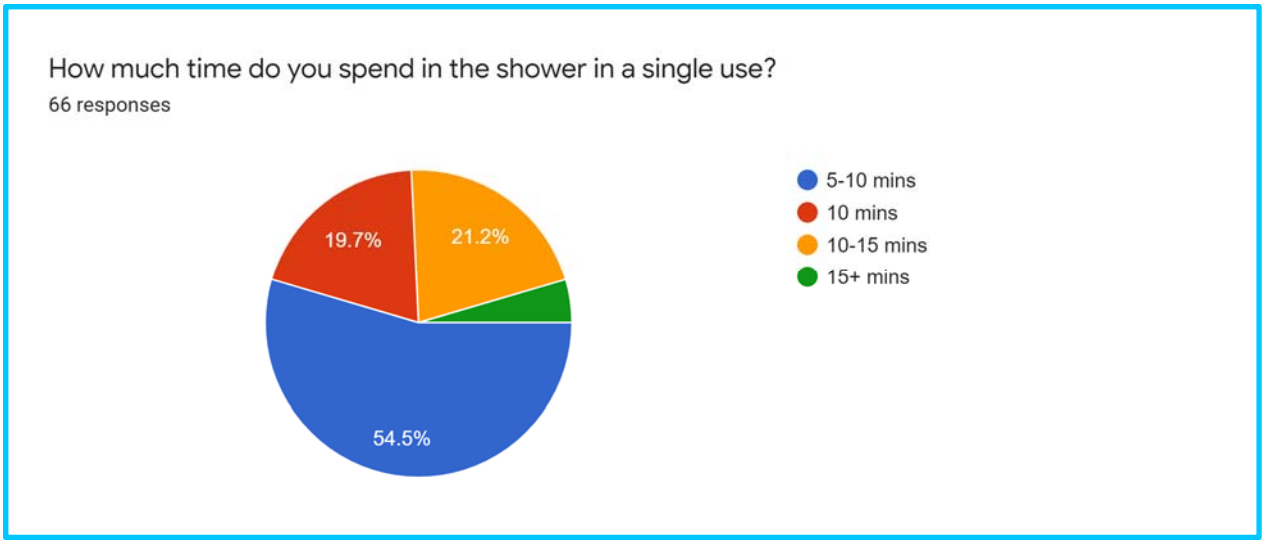
The majority of the people surveyed were concerned about their water usage, and the others were either not sure or not concerned.



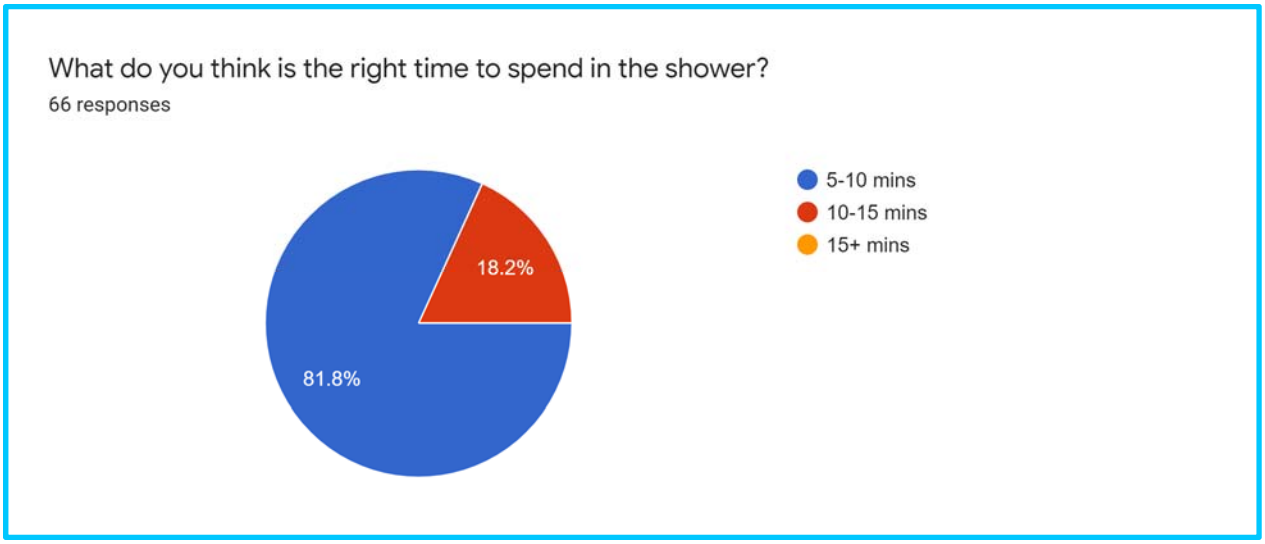
Most of the individuals had 3 showers in their house.



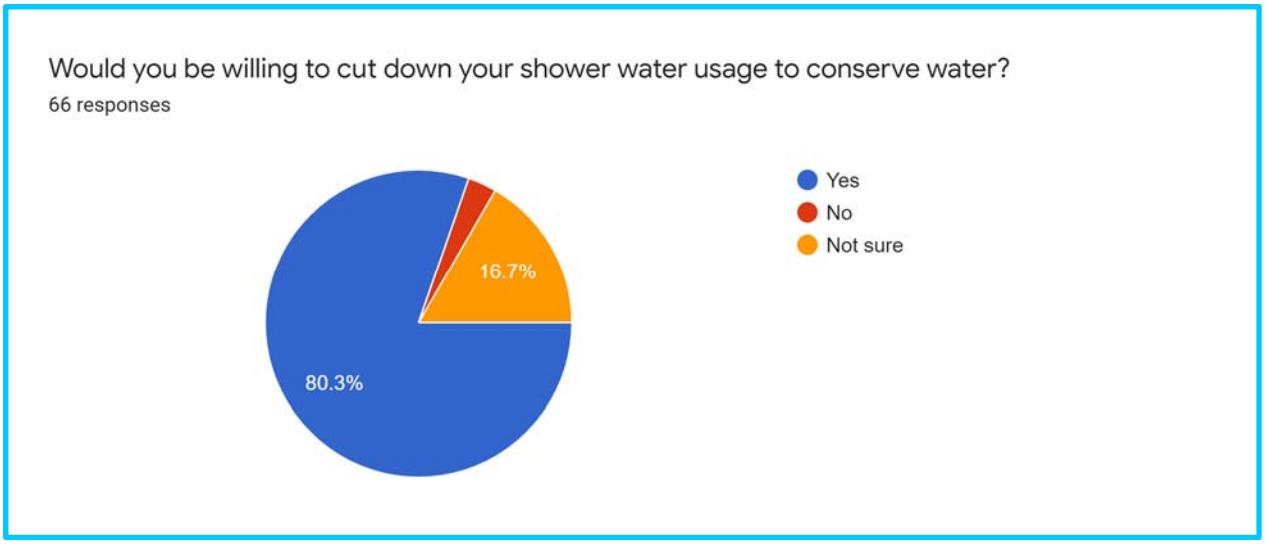
Many people only shower once or twice.



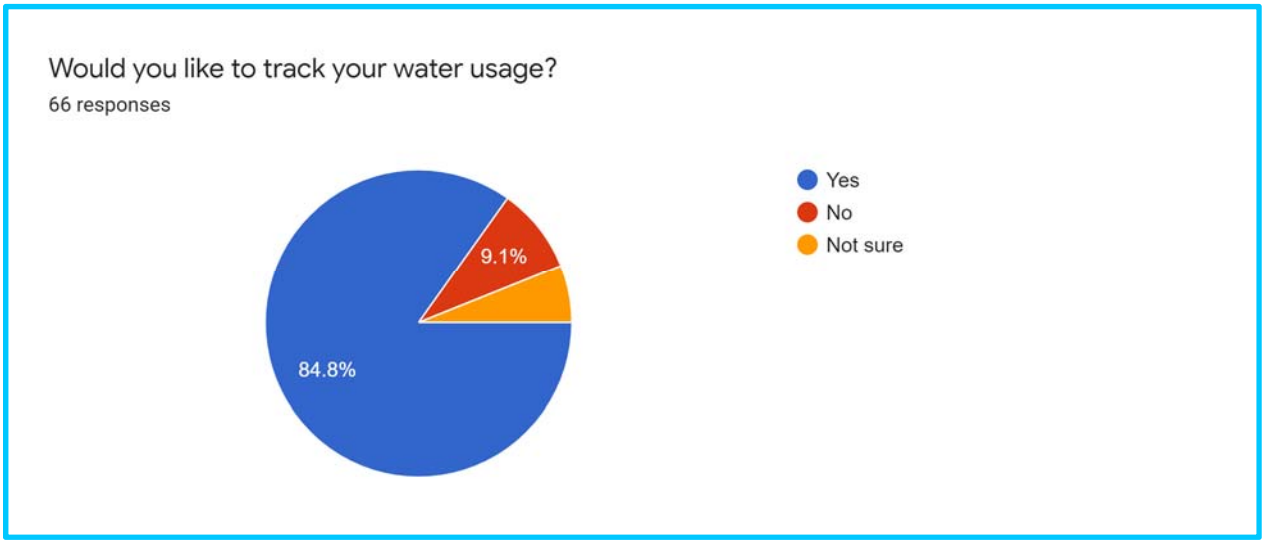
The majority of the survey participants regularly spend 5-10 minutes in the shower, and the smallest group of people spend more than 15 minutes.



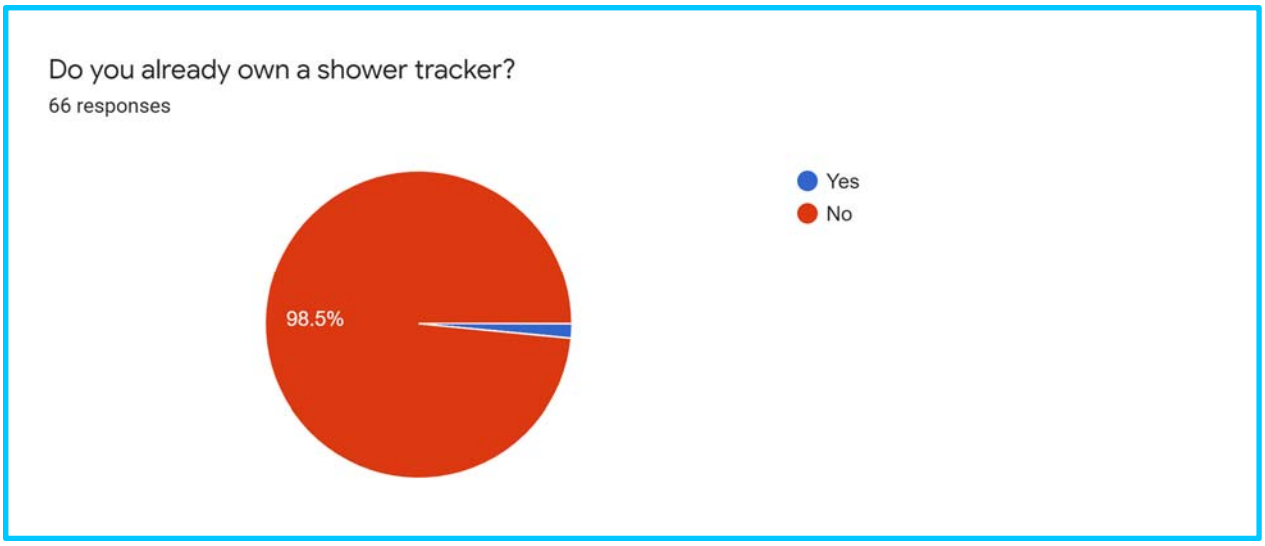
Most people think it's appropriate to spend 5-10 minutes in the shower, while some think 10-15 minutes is appropriate.



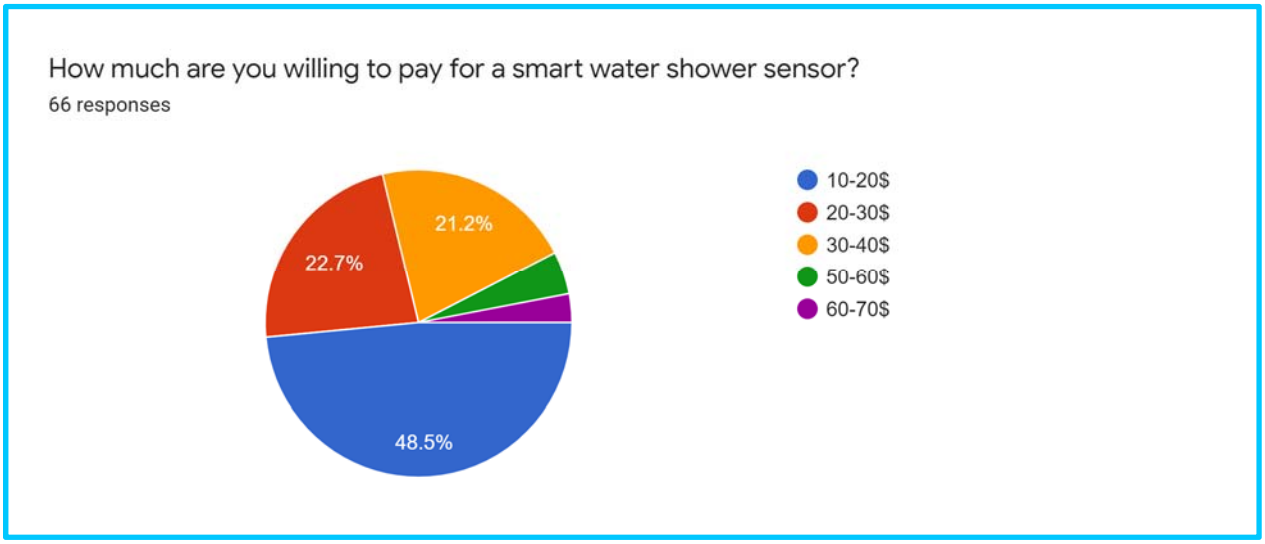
Many people would like to cut down water usage, some are not sure, and only 2 participants were not willing to cut down their shower water usage.



84.8% of people would like to track their shower water usage, while 6.1% are not sure and 9.1% would not like to.

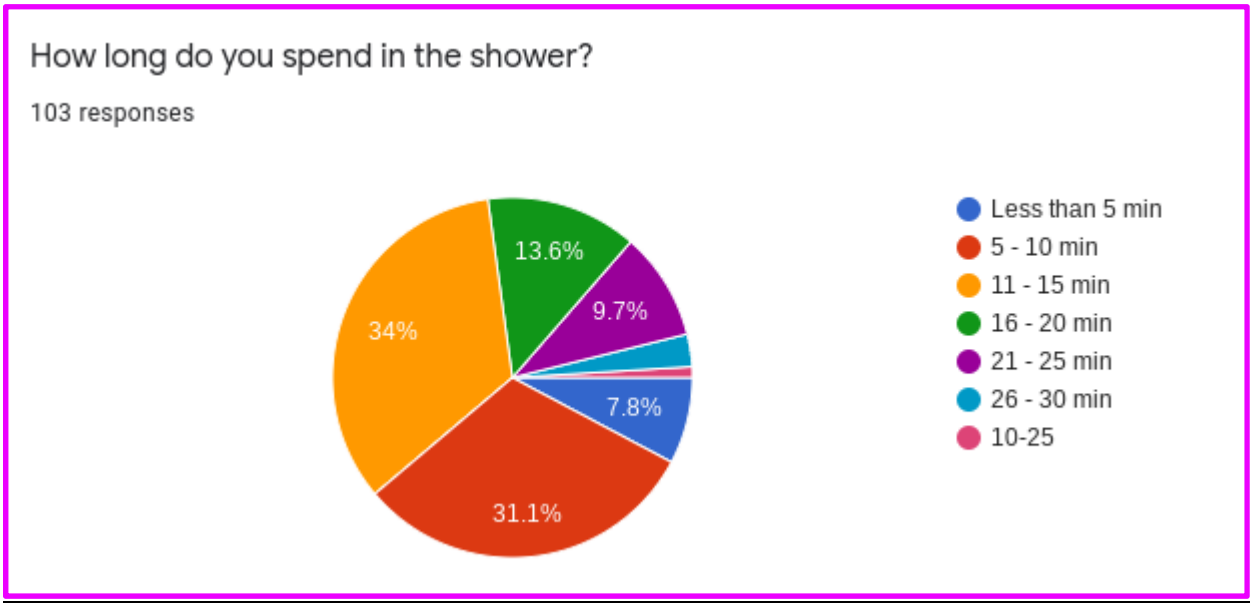


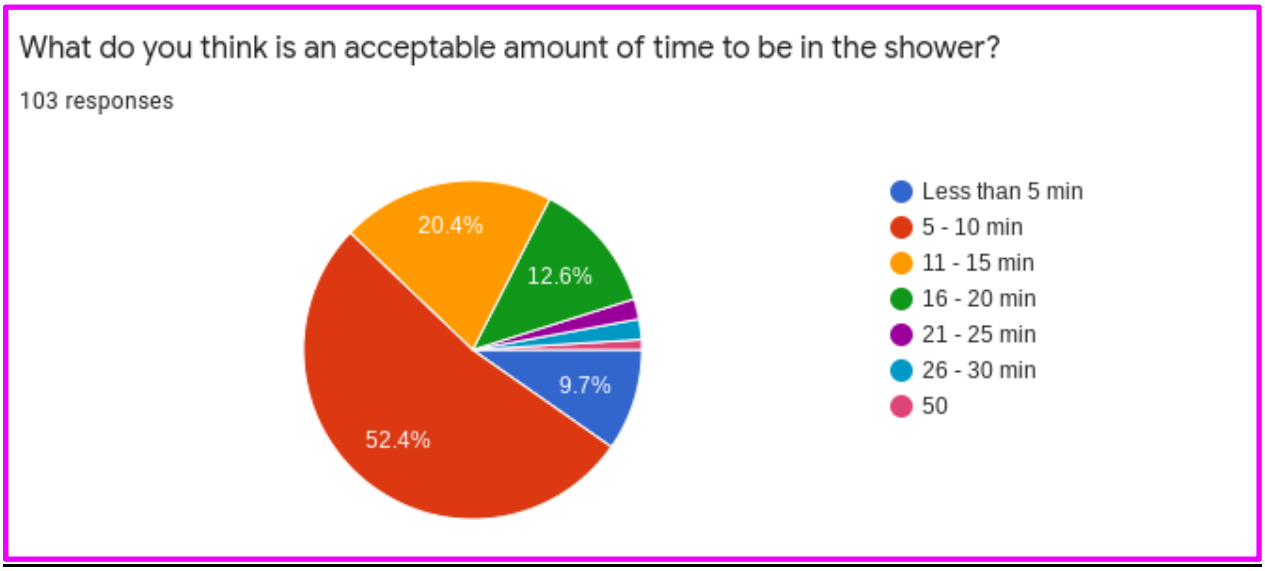
65 respondents did not own a shower tracker, while one did, and they claimed it was worth 11k.



Above how much money people are willing to spend on a shower water tracker.

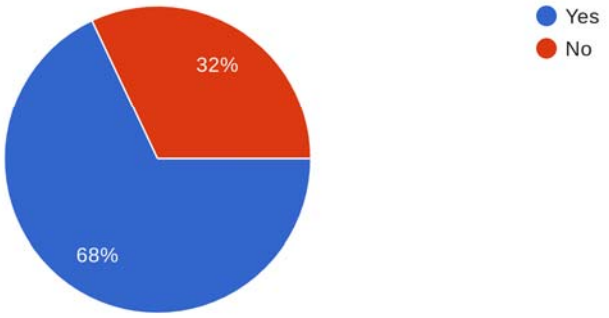
Results from Survey #2 (By Anish, 103 responses)





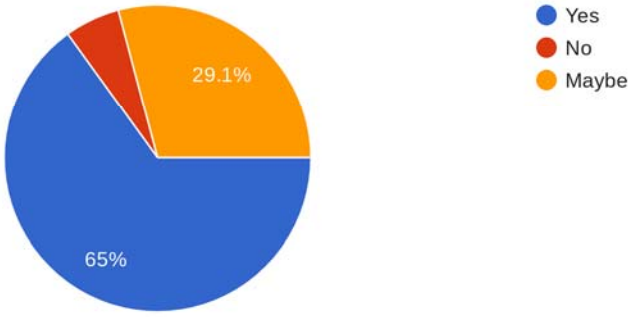
Are you concerned about how much water you are using?

103 responses



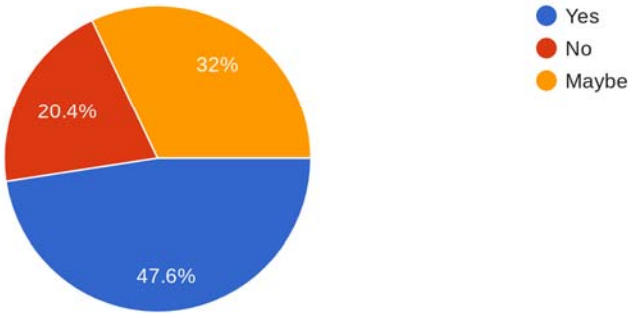
Would you support conserving water by taking shorter showers?

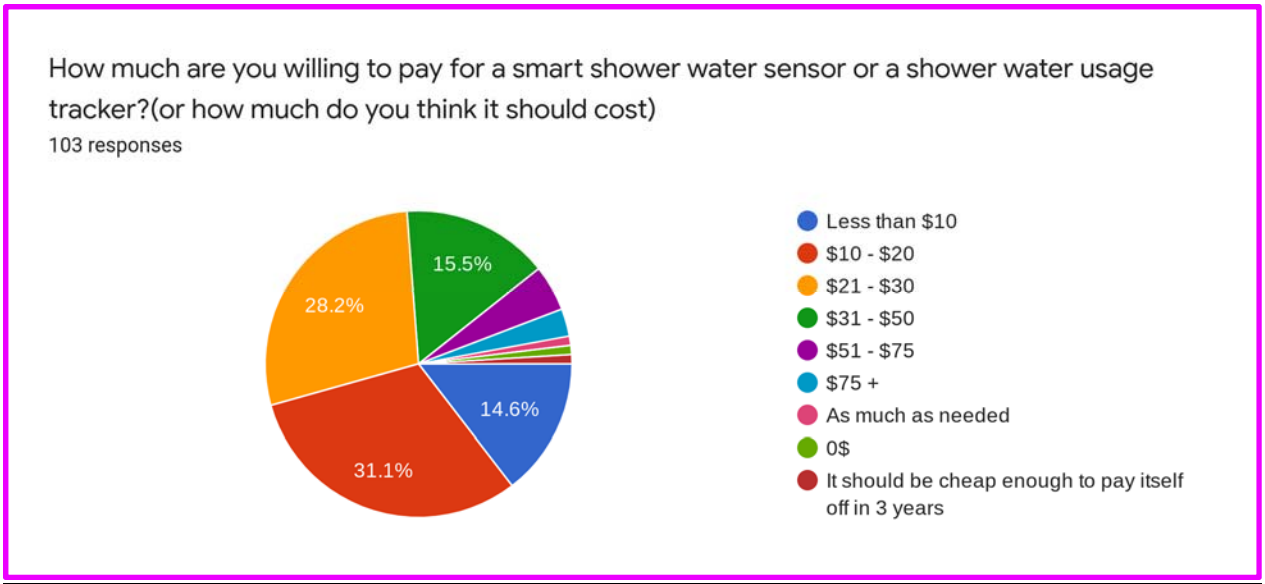
103 responses

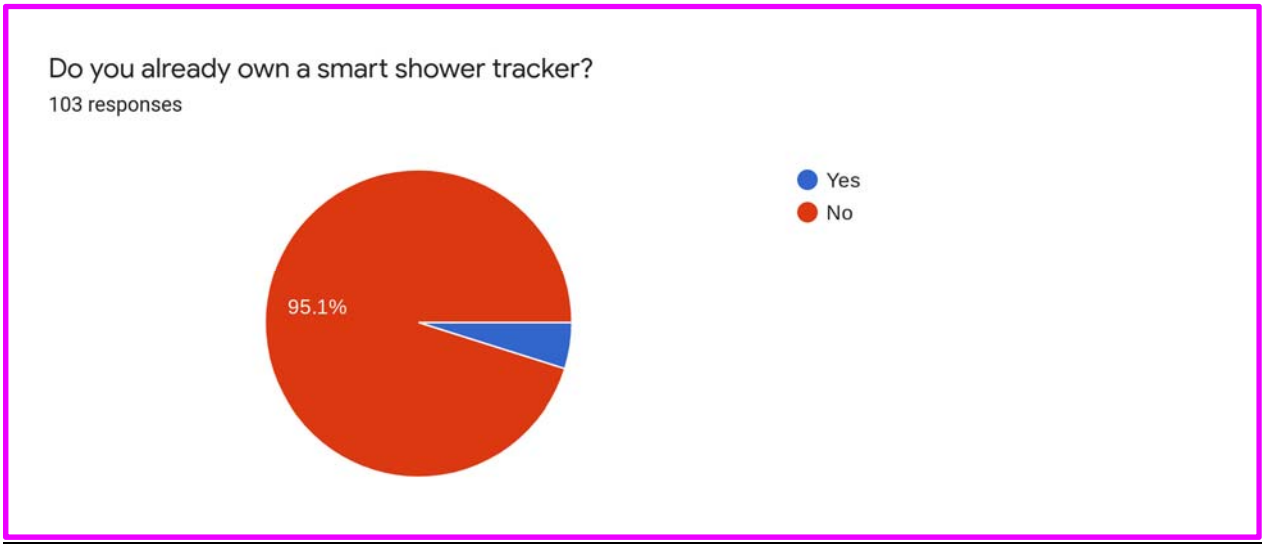


Would you like to track how much water you use in the shower?

103 responses







Results from Survey #3 (Advaith's, 62 responses):

Problems affecting the community/factors we considered:

Our product is unique because not only did we consider the opinions of the community, but we considered many factors that made the previous products in the market not effective.

What problems are in products currently in the market and how we decided to solve them:

- **Products are overpriced:** We planned to make our product cheaper by using products like the ESP8266, Active Buzzer and Hall Effect Sensor to create a smart device that only focuses on the necessary goals of tracking water and sending it to an App rather than fancy, impractical extraneous features.
- **Products are not safe:** While looking at product descriptions and reviews on websites like

Amazon and others, we saw that certain products had health risks like toxic chemicals and metals. We wanted to provide a safe way to save water, so we designed a prototype with safe products - low voltage, food safe plastics, lead free soldering etc and plan to enclose this in a waterproof case.

- **Most products are timers only:** We wanted users to not only know when to stop using water, but to be aware of their water usage patterns and to be able to see how much water they are using. That's when we decided to also create an app (connected by the wifi-transmitting chip) that shows users how much water they are using, to increase awareness. This aspect of our project is what really makes it unique and we believe it will have a strong impact on the community.

Our impact:

We've conducted four surveys with the same questions, each sent to different groups of people for more credible results, so we know where the community stands. Most people would like to cut down water usage, or they're unsure, and rarely anyone has a shower water tracker. We believe our product will make users more inclined to save water, since they can track their usage and be more aware of their patterns. Since our product is unique, easy to use, and affordable, many people can start conserving water and the water wastage rates will be significantly cut down.

Fairfax Water trip:

We visited the Fairfax Water headquarters and spoke with Erica Fox and Mukesh Inamdar, chemical engineers. We showed them a demo of our project, went on a tour of the headquarters, and learned about what this product could mean for the community. They both remarked at how innovative the project was and how they had never seen anyone try to conserve water with such a unique solution and thinking out of the box. They talked about how much this device would help families. Multiple adults have told us that they can relate since their teenage kid uses too much water, and this device will help tackle all of those water users at one. We were also told that our out-of-the-box thinking could help solve other problems too, since our generation is the future. They also said our water sensor could also be used in many other places, like the garden, the sink, and more, to spread our goal of water conservation.

Us entering the Fairfax Water headquarters.

Us with the engineers in the building lobby, which has a sign describing their water treatment

Us showing the engineers a video about our product with a demo

Us at the outside of the building after our trip.

In this picture, we put on our issued lab coats for when we entered the lab for the tour and demo.

eCYBERMISSION Survey Approval Form**

eCYBERMISSION team name: Aquatech

Team Advisor name: HIMA LANKA

Team Advisor email: hgadwala@gmail.com

Team Advisor phone: 703 2582283

Student usernames: 1600864, Remi_L, ani123, Tennisfort

School name: ROCKY RUN MIDDLE SCHOOL

School address: 4400 STRINGFELLOW RD, CHANTILLY, VA 20151

Describe the survey your team will conduct:

The survey will understand the water usage in individual families, especially shower water usage and their interest in investing in smart water monitor. No personal information is accessed.

Describe the participants you plan to distribute your survey to:

Friends & Aquaintances of parents of the participants

Project approved by school administration?

☒ Yes ☐ No

Approved by: Amy Goodwe

Title: Principal

Date approved: 12/20/19

Signature, School Administrator:

*Please have form completed, signed and dated BEFORE surveys are administered.

**As of August 2017, an IRB approval form (below) must be completed for all surveys as well as the information requested above.

THE INSTITUTIONAL REVIEW BOARD (IRB) for eCYBERMISSION Projects

An Institutional Review Board (IRB) is a committee that, according to federal law, must evaluate the potential physical or psychological risk of research involving **human** and animal (vertebrates*) subjects. All proposed human and animal research must be reviewed and approved by an IRB **BEFORE** experimentation begins. This includes any surveys or questionnaires to be used in a project. ***NOTE-** Vertebrate animals, as covered by these rules, are defined as live, nonhuman vertebrate mammalian embryos or fetuses, tadpoles, bird and reptile eggs within three days (72 hours) of hatching, and all other nonhuman vertebrates (including fish) at hatching or birth.

Animal studies must conform to the International Science Animal Experimentation rules. For information on the rules and the forms go to the Society for Science website.

An IRB at the school must consist of a minimum of three members. Additional members are recommended to avoid conflict of interest. The IRB must include:

a) The school science fair coordinator or school science teacher **(May NOT be the students' team advisor!)**
b) The school principal or administrator **and**
c) One of the following: a psychologist, psychiatrist, medical doctor, or medical professional (this can be the school or district licensed nurse).

Each school site must establish an IRB to handle human and animal related eCYBERMISSION projects. This will eliminate the need for approval of these studies from anyone other than your school.

Two basic questions need to be asked:

1. Are **humans** involved in the study?

    a. If Yes, and the human(s) *could* be harmed in any way, then the team advisor needs to ask the student to have a **medical doctor** or **physician's assistant** provide written certification that he/she has reviewed safe practices with the student researcher **prior** conducting the research and submit the certification to the IRB along with the IRB Approval form. Make sure the student understands that he/she cannot begin work on the project until IRB approval is obtained. BOTH documents, the medical professional's written certification and the IRB approval form must be included with the mission folder.

    b. If Yes, and it is obvious that the human(s) *will not* be harmed in any way, then the Team Advisor needs to ask the student to submit an IRB Approval form to the IRB. Make sure the student understands that he/she cannot begin work on the project until after IRB approval is obtained and all three signatures have been collected.

2. Are animals involved?

    a. If Yes, and the animal(s) *could* be harmed in any way, then the Team Advisor needs to ask the student to have a **veterinarian** review safe practices with the student researcher and check the condition of the animal(s) **prior** to and **after** conducting the research. Ask the student to submit the certification of both to the IRB along with the IRB Approval form. Make sure the student understands that he/she cannot begin work on the project until IRB approval is obtained.

    b. If Yes, and it is obvious that the animal(s) *will not* be harmed in any way, then the Team Advisor needs to ask the student to submit an IRB Approval form to the IRB. Make sure the student understands that he/she cannot begin work on the project until IRB approval is obtained.

All eCYBERMISSION projects involving animals or humans require approval by the school IRB prior to the start of any experimentation and the Team Advisor must retain the original form.

Projects must have a copy of the IRB and supporting documentation (if needed) attached (uploaded) to the Mission Folder before testing begins.

INSTITUTIONAL REVIEW BOARD

APPROVAL FORM

Student(s) User Name(s): 1600864, Remi-L, ani123, TennisFort

Grade: 8 **Team Advisor:** HIMA LANKA

Team Name: AQUATECH

Brief Description of Project:
The students are designing a smart shower water monitor using hydroelectricity and IoT architecture. They do not intend to test on any animals or humans. Project uses <5V electricity and is safe.

Team Advisor: Please sign here if the project proposed is a viable eCYBERMISSION Project in which neither animals nor humans will be harmed.

Team Advisor Approval Signature: L. Hima **Date:** 12/18/2019

IRB Waiver of Written Informed Consent for Human or Animal Participation

The IRB may waive the requirement for documentation of written informed consent/assent/parental permission if the research involves **only minimal risk *and* anonymous data collection *and* if it is one of the following**: (NOTE: This statement only applies to providing the written certification mentioned in 1a or 2a above).

- Research involving normal educational practices.
- Research on individual or group behavior or characteristics of individuals where the researcher does not manipulate the subjects' behavior and the study does not involve more than minimal risk.
- Surveys, questionnaires, or activities that are determined by the IRB to involve perception, cognition, or game theory and do NOT involve gathering personal information, invasion of privacy or potential for emotional distress.
- Studies involving physical activity where the IRB determines that no more than minimal risk (Daily Activity) exists and where the probability and magnitude of harm or discomfort anticipated in the research are not greater than those ordinarily encountered in DAILY LIFE or during performance of routine physical activities.

If there is any uncertainty regarding the appropriateness of waiving written informed consent/assent/parental permission, it is strongly recommended that documentation of written informed consent/assent/parental permission be obtained.

HUMAN or ANIMAL SUBJECTS
Permission Slips needed? (see above to determine) Yes ☐ No ☑ (Scan and attach slips to Mission Folder)
Check-up of Human or Animal Subjects required by Doctor, school nurse or Veterinarian? (see above to determine) Yes ☐ No ☑ If yes, Doctor's, Nurse's or Veterinarian's (before and after experimentation) current evaluation report must be attached to Mission Folder.

APPROVALS –

Principal / Administrator Signature — Date Reviewed: 12/20/19

Doctor or Medical Professional Signature MD — Date Reviewed: 12/23/19

Science Fair Coordinator or other Science Teacher Signature — Date Reviewed: 12/20/19