University of Ottawa

Department of Engineering, 1st Year

GNG 1103-C: Engineering Design

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Abstract

This report fully documents all the details of the hydroponic project we did in this course. We were given the task to make a hydroponic system for under $100 that would solve critical problems of our customers/users. The client/user were teachers and children from the company "Growing Futures". We followed the design thinking process of empathize, define, ideate, prototype and testing throughout this whole project. First, we interviewed them in class for information to better understand the problem. Once we understood the problem, as a team, we had to get together to sketch and brainstorm as many ideas as possible. We then pick an idea and schedule/plan our design. We would then have to create 3 physical prototypes and test them so that we could finally show them to the customers. At first, we built the prototype out of cheap material but at the two last prototypes, we had to build them out of real materials that would be on our final product. We would receive feedback by the customers for each prototype. With that information, we would change and improve our concept. On the final design day, we were able to showcase our final prototype to judges.

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Introduction

The kids from Growing Futures are looking for a better hydroponic system that delivers a better dripping system, better portability, compact and has a better reservoir system with monitoring. Hydroponics trending recently due to their higher plant growth rate and the ability to grown indoor easily. There's a huge market for them and they are gaining popularity. Thus, there is a huge competition to innovate hydroponic systems to be cheaper than the more expensive solutions on the market. Thankfully, we have been given a chance to participate at creating a hydroponic system that solve many of their issues while keeping the price as low as possible.

Our solution had to be simple and easy to use because our main users were young children. The user of our hydroponic system must be able to refill the reservoir, be table height tall to plant the seeds, clean the system and function a simple application. Thus, our team created a hydroponic system that solves the inconsistent water delivery, delivers a bigger reservoir with tracking features, is compact, is short and can be transported around with a low budget of $100.

What sets us apart from our competitors is that our hydroponics system is capable of monitoring water levels via mobile app through bluetooth connection. Our system is also disassemblable and is extremely easy to move around and set up.

Main Body

EMPATHIZE

For our empathizing phase, we gathered information and classified it into client statement/ needs. We also interpreted the needs that were most important by making a priority list.

Client Statements/Needs

Remodel the current Hydroponic System to increase efficiency while keeping the following statements in mind:

- Current System uses artificial lighting, light switches on and off every 12 hours.
- New system must have a capacity of at least 20 plants.
- Must be environmentally friendly.
- Current system’s water drip is very inconsistent.
- Must be modular.

- Must be able to move with ease(through an elevator, small, light).
- Cost was $1500-$1800.
- Ensure that the light spectrum is within the flowering spectrum.
- Automatic water pump is needed, once a certain low level of water is reached.
- Create Label
- Possibly monitor water level or pH level using an App
- The reservoir is preferably clear.
- Some method to prevent rust.
- Current reservoir holds 76 Litres.
- 10-15 Litres of water is added every week.

Interpreted Needs Prioritized

1. Holds at least 20 plants
2. Electric and hydro conservative
3. Consistent water drip rate
4. The total system is made up of small parts easily removable
5. Easy to move, light and compact
6. Material of reservoir must be transparent
7. Rust-resistant material
8. Bigger volume of reservoir

DEFINE

When defining our problem, we wrote a short and concise problem statement. We also performed a benchmark of other products to determine our target specifications. We had to define our design criteria: the functional features, the non-functional features and the constraints.

Possible Solutions

- Move water above plants, gravity would take care of distributing the water.
- Sticker Labels - Cheap
- Cardboard material(Issue with possible water leaks).
- Scrap Metal - Cheap
- If all other materials are too expensive, cheap chinese plastics are an option.

Problem Statement

The people of Growing Futures requires a hydroponics system that can grow the most amount of plants, in the most compact and energy efficient system that is easy to transport.

Benchmarking

Comparing multiple proprietary solutions

Design Specification	Hydroponic N.F.T system	Zipgrow Farm Wall	NutriTower
Cost	$99 (CAD)	$369.99 (CAD)	$159.99 (CAD)
Weight	13 lbs	50 lbs	75 lbs
Dimensions WxHxL	Width : 39” Height: 11” Length: 20”	width : 6’ 6’’ Height: 67’’	Width:10” Height: 71” Length: 32”
Reservoir size	15 - 20 L	Not specified	36 L
# of plants it can hold	36	48	40
Material pipe	PVC	PVC	Metal conduit
Corrosive safety	Not corrosive	Not corrosive	Has anti-corrosive layer

Table 1. Benchmarking

Design Criteria

Holds at least 20 plants	Maximum length/width while maintaining a compact area (metres
Electric and hydro conservative	Low electric usage (Volts)
Consistent water drip rate	Exiting water speed(m/s)
The total system is made up of small parts easily removable	Breakable(disassemble)
Easy to move, light and compact	Weight(lbs)
Material of reservoir must be transparent	Translucent

Rust-resistant material	Corrosion-resistant
Bigger volume of reservoir	Water reserve(Litres)

Table 2. Design Criteria

- For 20 plants, the volume and the dimensions of each plant needs to be known. Moreover, the area of the land on which the plants are based upon, should also be figured out.
- For a consistent water drip rate, the flow rate of the water (the velocity and the force with which the water flows out) needs to be determined.
- If the product is easy movable and should be light and compact, its weight needs to be measured. Along with that, the portability of the product also needs to be taken into account.
- Rust-resistant material also needs to be kept in mind for the design criteria. A corrosion-resistant material will subside for this problem.

Functional Requirements:

- Light is on for 12 hours automatically switches off for 12 hours.
- Automatically pump water to reservoir .
- Light rays within the flowering spectrum

Non-Functional Requirements:

- Made out of metal
- Fold on wheels
- Hold about 85 Litres
- Minimum 20 Plans
- Artificial Light
- Visible LOGO placement
- Transport through elevator

Constraints:

- $100 budget
- Small enough to transport around a school environment and through small elevators
- Design must be made modular to some degree

- Must be an environmentally friendly project
- Must be easy to use for kids

IDEATE

In this phase, our team came up with as many solutions as possible and sketched them out. Then, we categorized them and only picked 3 concepts per person.

Solution sketch models (only a few):

Yves Larocque

Understanding that not all of the non-functional requirements can be reached with the restricted budget, each concept will be focused on one or two of the non-functional requirements.

Concept 1:

Description: My design focuses on the students wish to maximize the length and the width of the system while maintaining a compact area. Students mentioned the importance of holding the maximum amount of plants possible(no less than 20). More plants will result in a higher volume of production and higher revenues. The following sketch illustrates a model capable of holding 25 plants. Although this model will increase production, its structural frame could be difficult to maneuver.

Sketch:

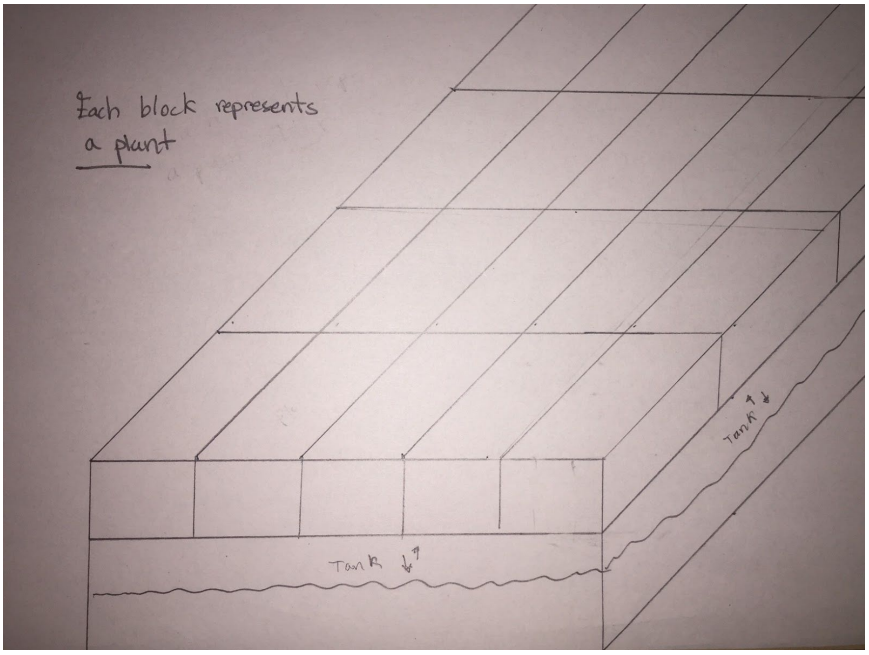

Figure 1. Yves's Concept

Kathit Patel

The design concepts will majorly focus on the safety and reliability part of the non functional requirements to see how it impacts the plant design.

Concept 1:

This design will meet the demands of the clients who want their plant system to be safe to use. It will focus on how the usage of paints to cover the borders of the plant design could lead to water contamination. A non porous layer of material should be used to construct borders to avoid water contamination. These non porous boundary layers could be in circular or rectangular form.

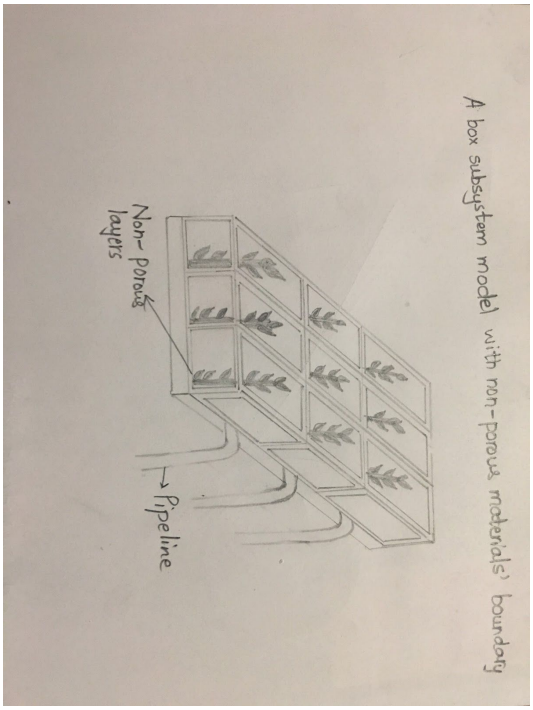

Figure 2. Kathit's Concept

Jun's Concept

Rotating egg/dome

This concept goes to mainly solve the 12 hour shifts for the plants to get light. It involves a dome like piece that contains the plants which is fixed onto a motor that rotates. The fixed led goes on the wall and is supported by its own frame. The reservoir is then connected to the egg via a tube. This structure is compact and is easy to carry and install. It is also visually appealing.

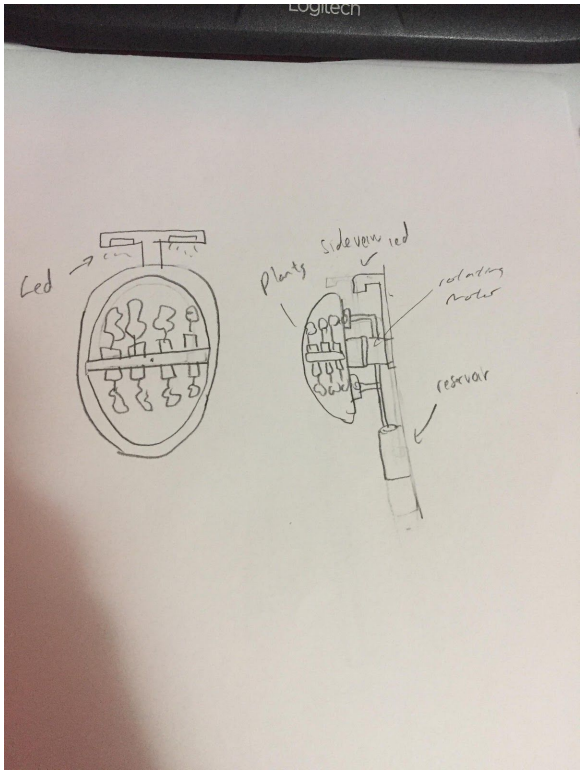

Figure 3. Jun's Concept

Ethan's Concepts

A possible method to reduce cost would be place the water tank above the plants. This would remove the need for a pump entirely as water would just drip directly down from it. However, the hydroponic design is meant for this use of children.This makes a top mounted water tank impractical as it would almost impossible for them to manage. Instead, a water tank resting on the floor, with an efficient method of feeding the plants is required. As well, to help reduce the weight of the whole structure, most, if not all parts, will be detachable. This will make it easier to transport, and easier to manage as well.

Concept 1: Root feeding system

Instead of using a drip system, another method would be to use gravity to help water the plants. By having the plant roots grow down into tubes/containers, water can then run through these to feed the plants. By having the water run through the roots, we feed the plants directly, lowering water loss. As well, by doing so we keep the whole system cleaner as leakage is a lot less likely. In this design there would be four parts. The water tank, the stands that attach to the tank, the tubes with the plants that attach to the stand, and the lights that attach to the front of the tank. At the ends of the tubes there will be a tube facing downwards. This is to attach to other tubes/the tanks to allow the water to flow through.

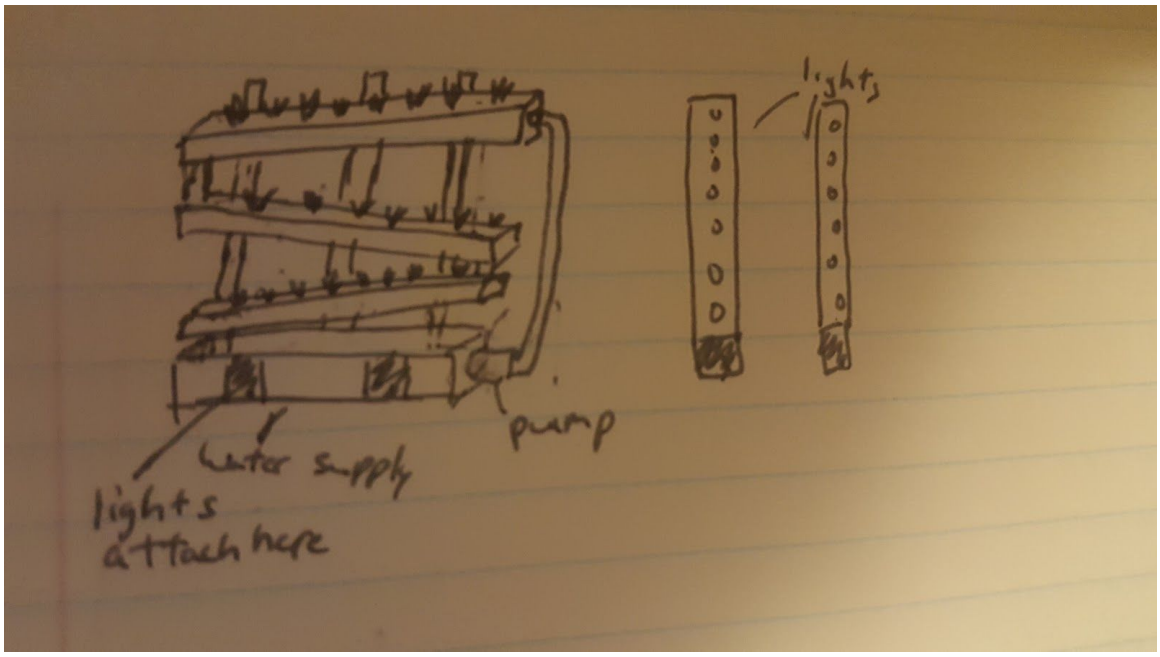

Figure 4. Ethan's Concept

<u>Nick's Concepts</u>

Concept 1: Circular Hydroponic System Layout

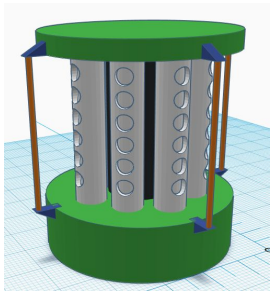

Figure 5. Nick's Concept

This design was created to solve size constraints. Contrary to the hydroponic system used by Growing Futures is a linear and flat system put on the wall, this system will be shaped in a cylindrical manner. Thus, they both have the same surface area but the cylindrical shape has some advantages. It won't take so much room vertically. Also, in this picture, the hydroponic system can hold 48 plants.

PROTOTYPE / TEST

After picking a solution, we worked hard on design and modeling it. For our application, we created a simple app without adding all the features to if it would work and stress test it. We also

build many prototypes of our hydroponic system. Our team was able to further test the hydroponic system.

Proposed Solution

The proposed solution that our team came up provides a compact area that is easy to clean, accessible for children and provides a clear slot for branding. Further our design solution comes with an app that allows the user to monitor the water level through bluetooth connection. Below are few visuals from our final product.

Figure 6. Growing future logo displayed on the side of the hydroponic

One of the great features of our design layout is that our hydroponic system can clearly show the logo on both sides without being obstructed by the growth of plants.

Figure 7. The system contains 4 PVC pipes.

Figure 8. The walls of the hydroponic system are built with strong wood

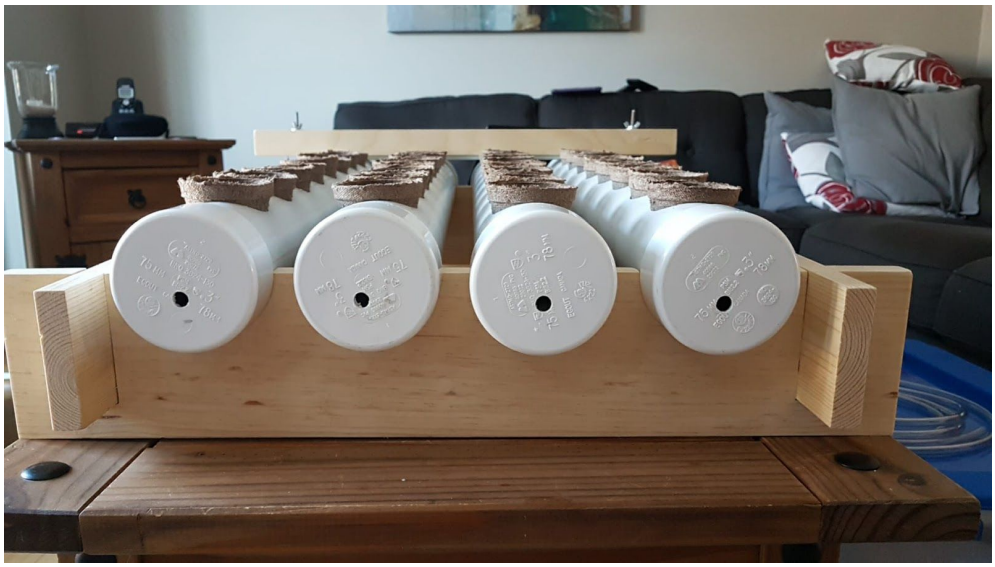

Figure 9. Each Pipe is able to contain 8 plants

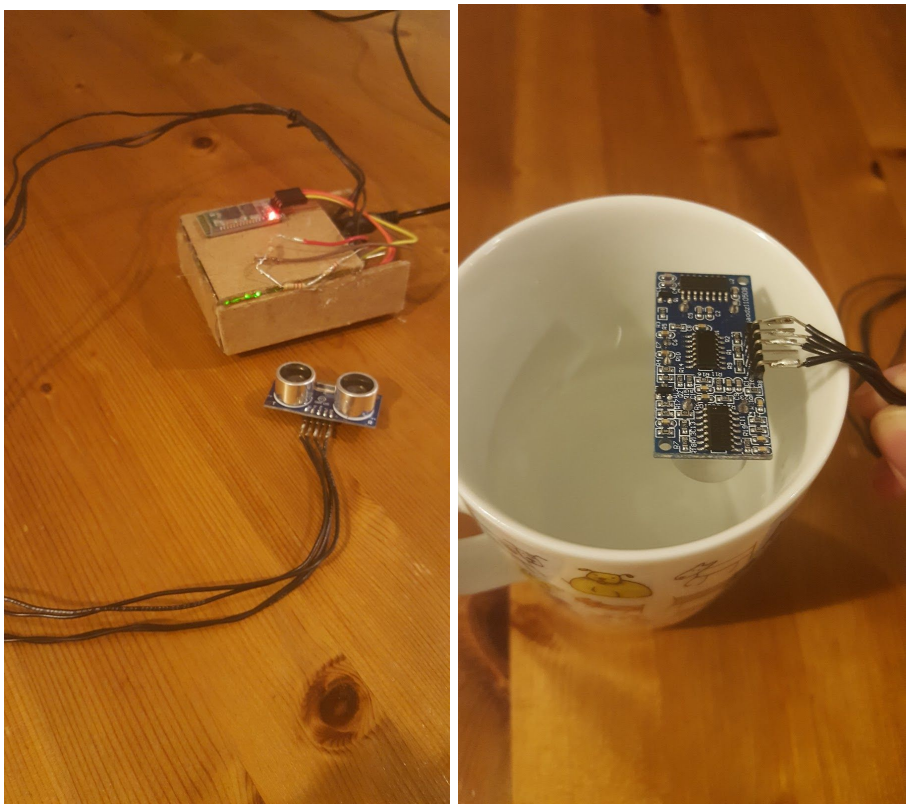

Figure 10. Arduino with bluetooth along with sensor

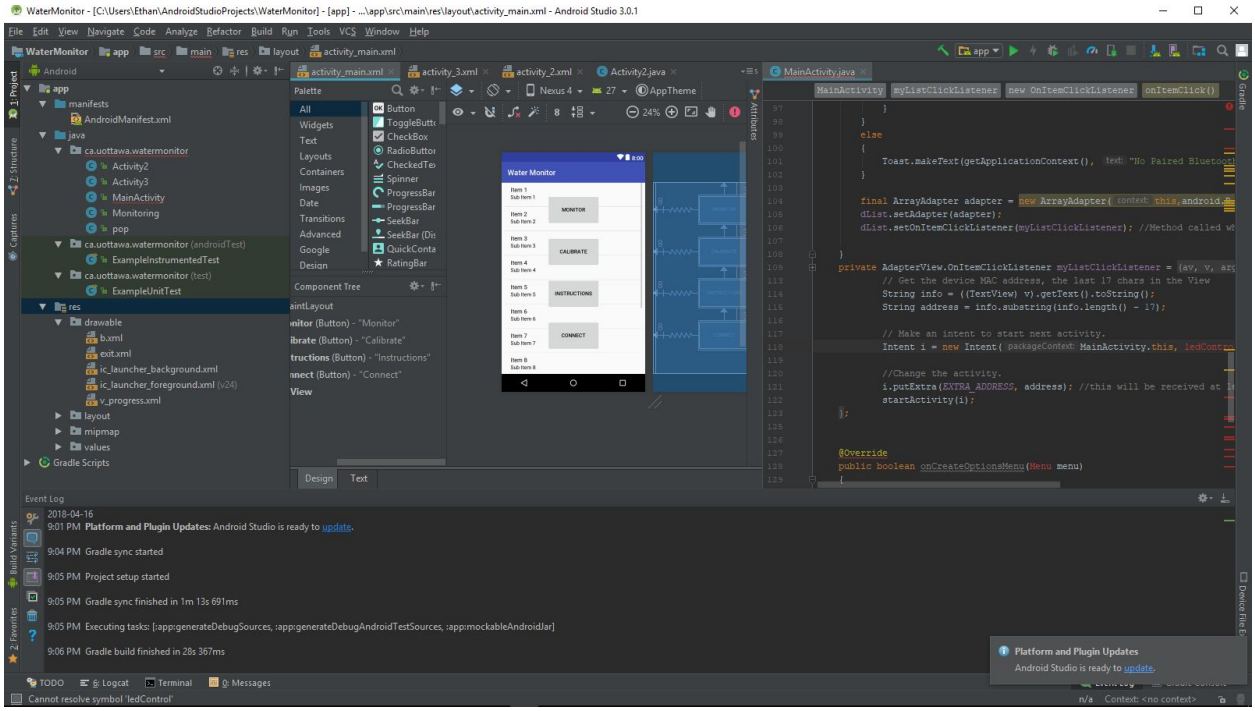

Figure 11. Early development of java app in Android Studio IDE

Modelling

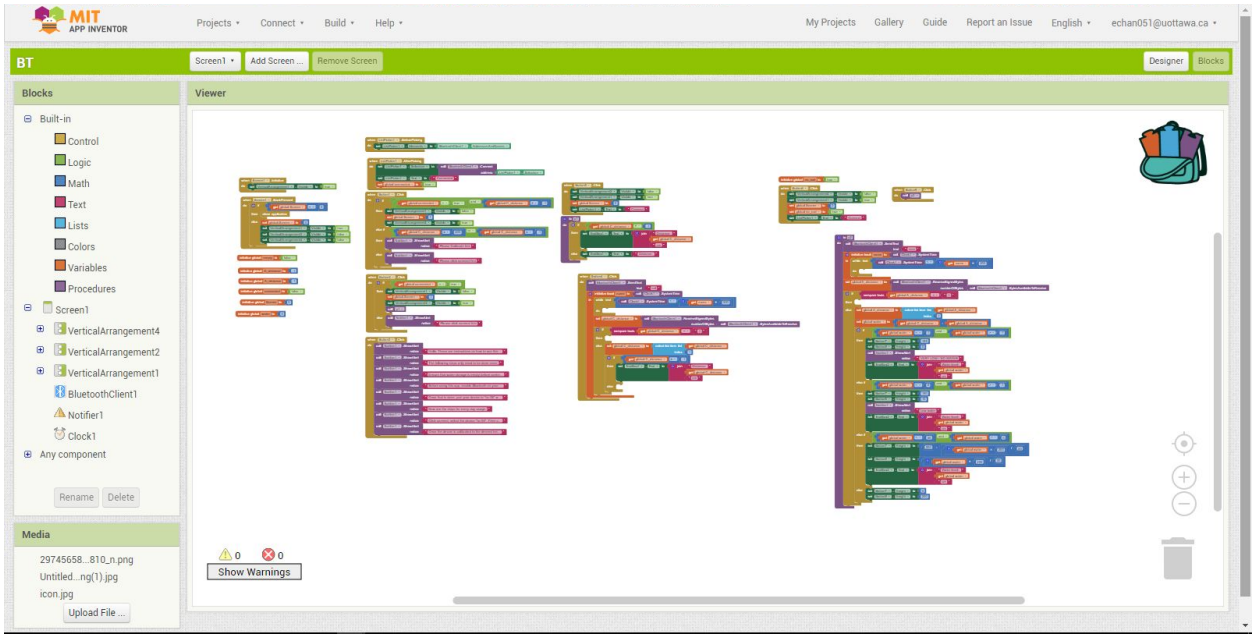

Figure 12. Development of app in MIT App Inventor 2

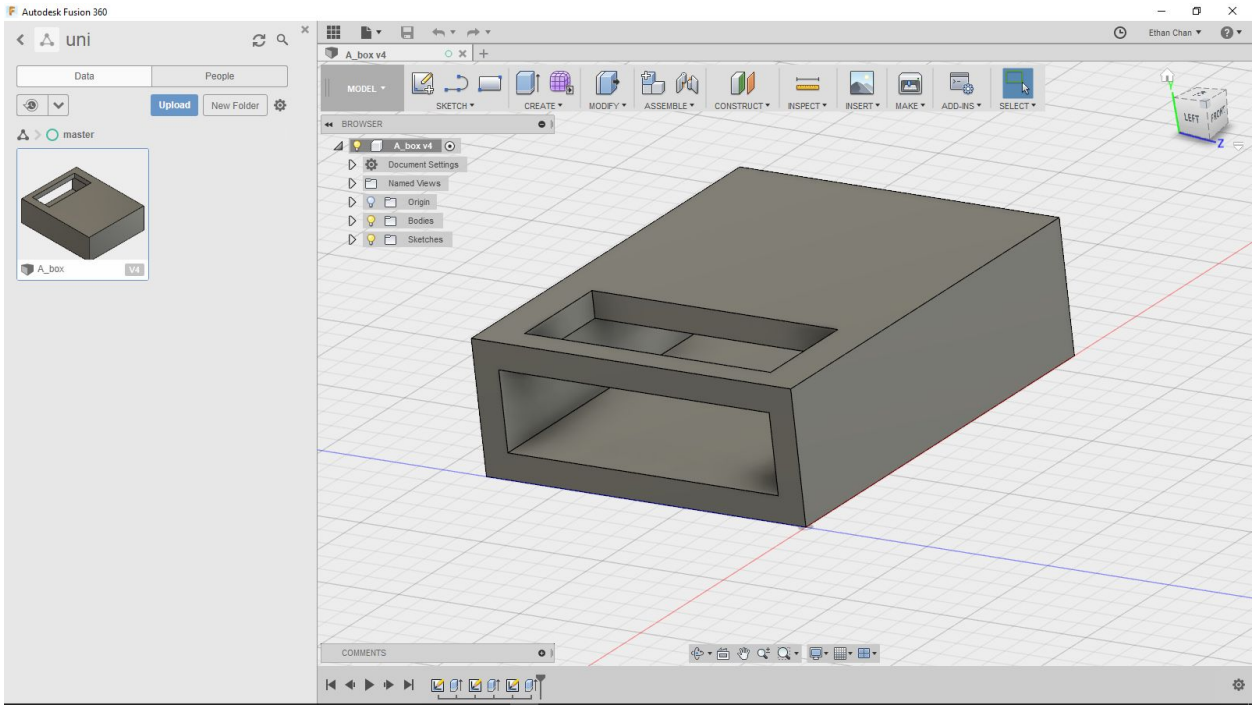

Figure 13. CAD drawing of arduino case in Autodesk 360 Fusion

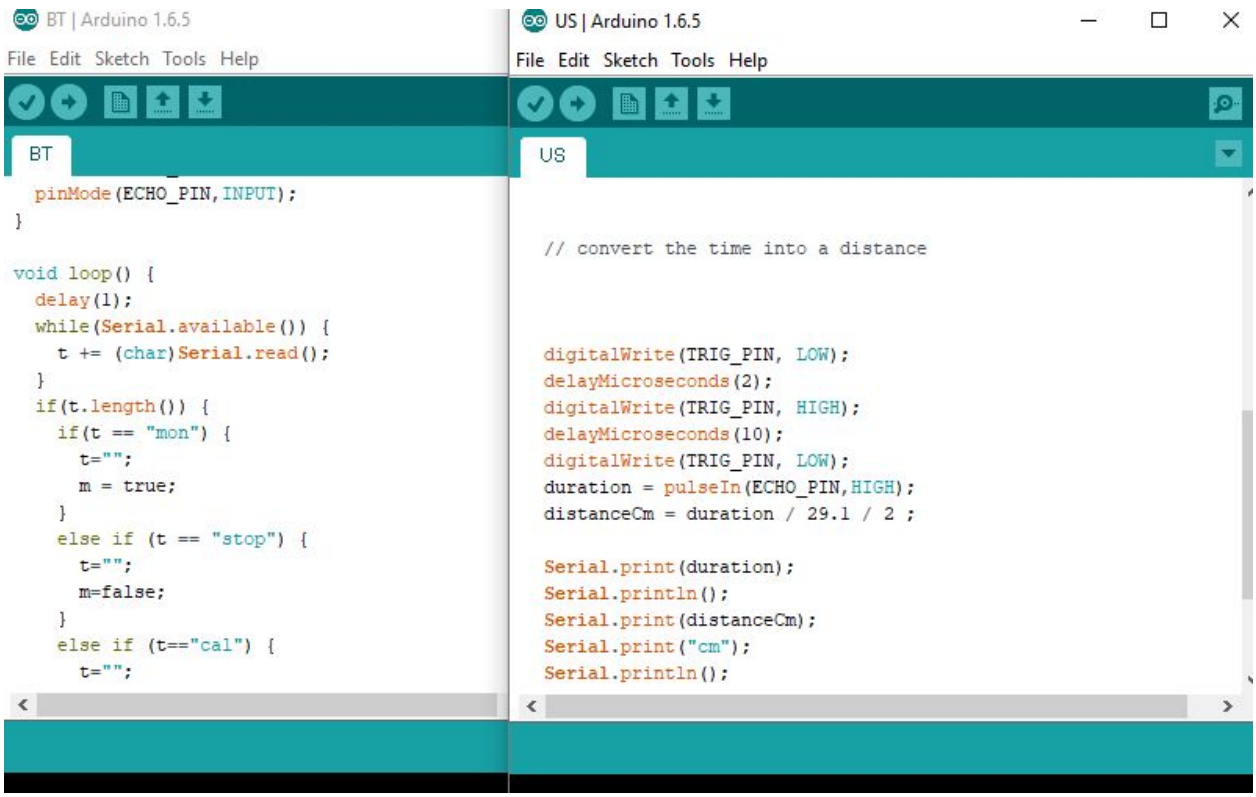

Figure 14. Ultrasonic and Bluetooth program in arduino code

Prototyping strategies and test results

A majority of our testing was done through analytical prototyping. As shown in modeling, the analytical tests were done by passing values into arduino and java code. Afterwards, to confirm that the components functioned properly, quick tests were done to ensure that the right data was being received.

We also did a physical prototyping test. The test was to run water with a pump from the reservoir to the entire hydroponic system and back. This test proved successful and we had enough water height build up to reach the net pots for the pants. Thus, our system can feed water to the plants at the perfect level.

Conclusion

In conclusion, the hydroponic system requirements of a good dripping system, better portability, compactness, and a better reservoir system with monitoring were met. Both, the need for innovation and the necessity to thrive through the competition that this growing field of hydroponics offers, were achieved. Along with resolving problems related to this field, we were also able to make it as economical as possible. Our hydroponic system, as well as the app that monitored and calibrated the water level, had to be user friendly, since most of the users of our product were young children. By taking all the system requirements and customer and user needs

and wants into account, our team designed a hydroponic system that solved the problem of inconsistent water delivery, delivered a big reservoir with tackling features, was compact, and was easy and short enough to transport with a cost as low as $100. Something that differentiates us from our competitors is the fact that we have used an app that monitors water levels, and also is attractive for the users (young children). Overall, based on all the needs and wants and going through the process of design criteria, and design thinking, our hydroponic system was overall a success, and was satisfactory for the users.