Prototype I and Customer Feedback

Genius Troop

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Abstract

This document outlines a plan for creating the first prototype and the data obtained through building the first prototype and feedback. In addition, the document includes an updated budget and design modifications based on customer feedback. The document explains how the prototype 1 and 2 will be used to test critical systems of the design. Finally, the document summarized the results of the design review and prototype one.

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Prototype 1

CAD Design

The following cad pictures are similar to the designs presented in deliverable E they are modified to reflect the change to foam and the cup holder redesign.

Figure 1: CAD Design Left Side

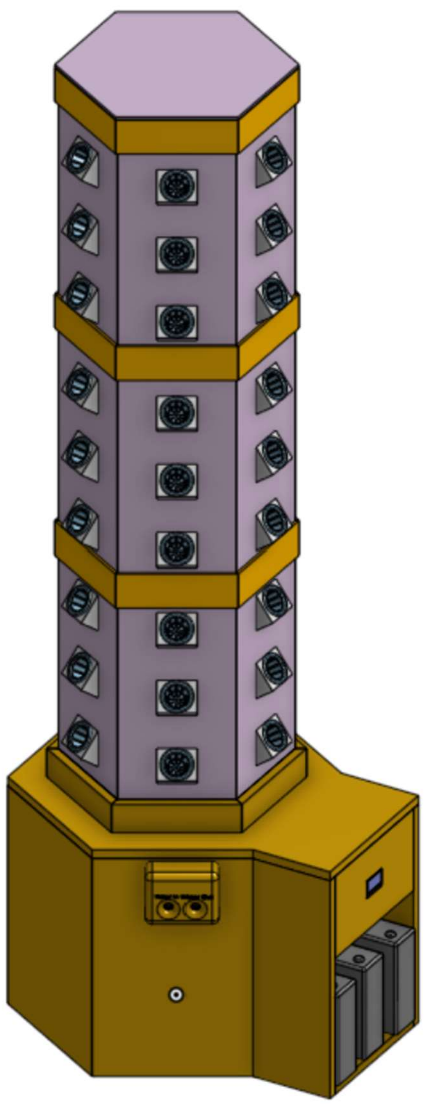


Figure 2: CAD Design Right Side

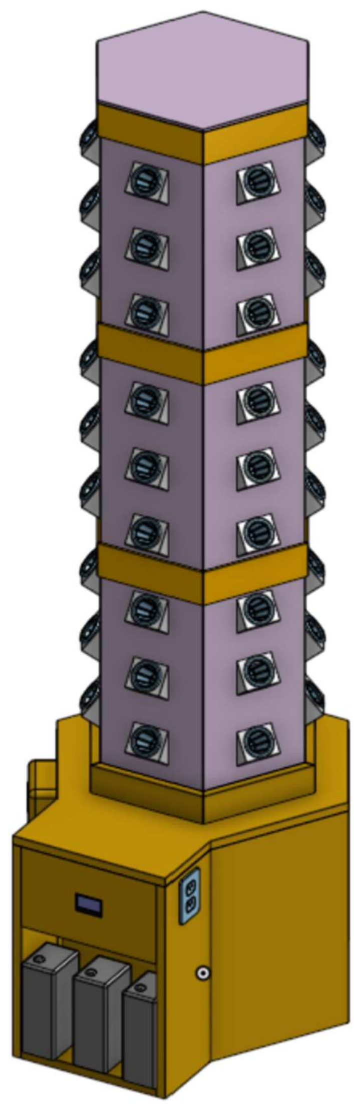


Figure 3: Modified Cup Holders (inside view)

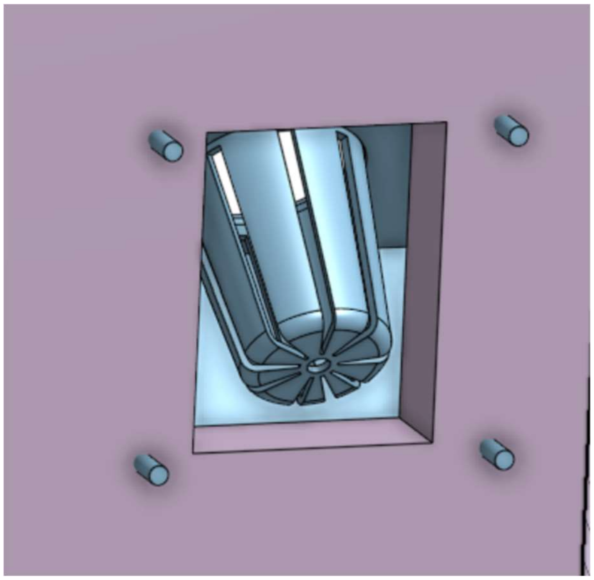


Figure 4: Modified Cup Holders (outside view)

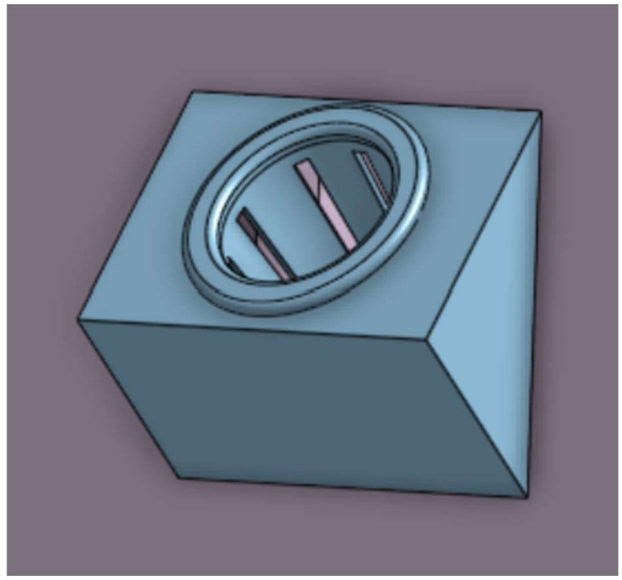


Figure 5: Home Screen Design

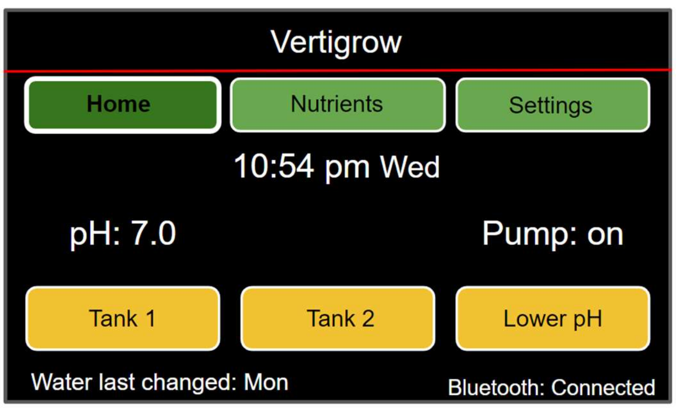


Figure 6: Nutrient Screen Design

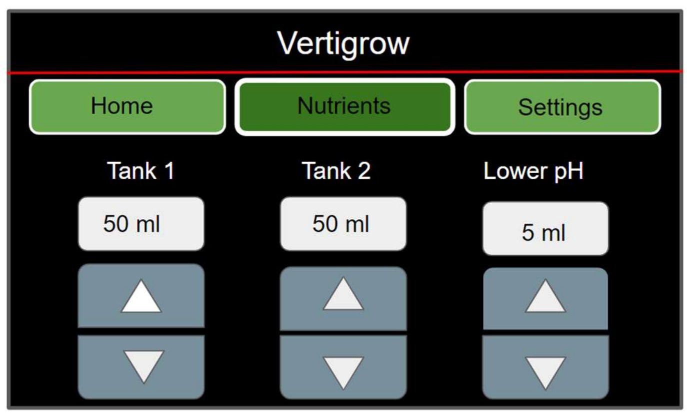
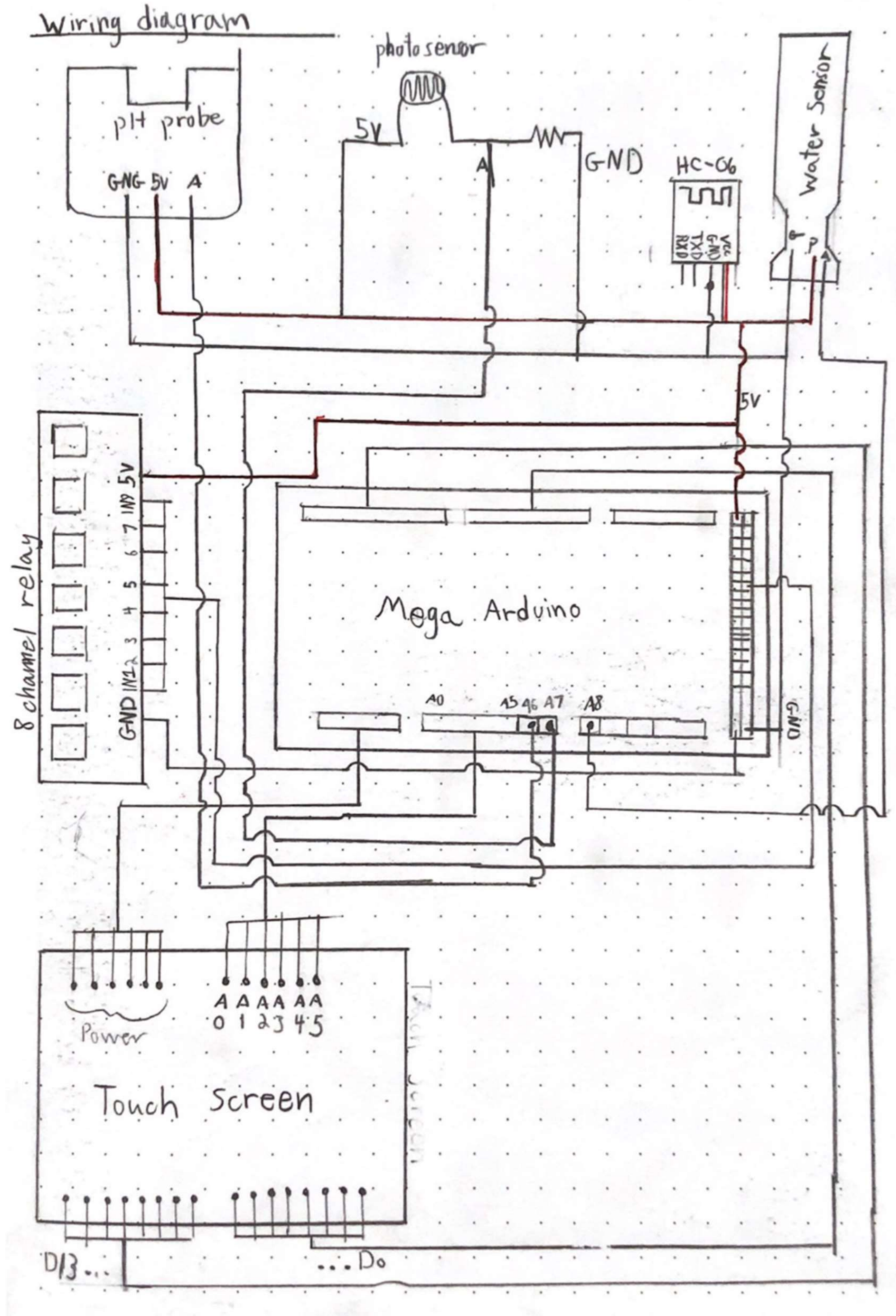


Figure 7: Nutrient System Wiring Diagram



Nutrient electronics

Unlike the other systems, for the nutrient system we decided that we should invest more money into protype one. We wanted to ensure that we would be able to manage the coding of the system as well as test to see if the electrical components that we picked for the system were sufficient. Unlike the building materials for the structural system the electronics used in prototype 1 will be used in the final design as well as the code developed. We decided this would allow us to test the code we developed to provide enough time to work out the bugs in the code.

For the nutrient prototype we will have three main pieces of hardware. The mega Arduino, the touch screen, and the 8 channel relay. With these three electrical components we will be able to test the code that displays the screen and runs the touch screen. Then with the relay we can test the timer functions for emptying/filling the tank, turning on/off the pump, and controlling the lights. We will be unable to test the Arduinos response to the 3 sensors and we will not include them in prototype 1 due to their cost.

The objective of prototype one is to test the code written for the Arduino for reliability, user compatibility, and efficiency. The first step will be to try out the touch screen to see if it is changing screen view and all the touch points are working. Then, we will get an outsiders opinion (such as TA's) on how easy the settings are to navigate. Finally, we will test the system's reliability by putting the arduino through a series of tests. Some of these tests will include testing to see if the arduino can keep track of the day and time, if the relay is triggered to change the system's water and nutrients, and if the warning system can detect a high or low pH level and alert the user.

Structural system

With our recent decision to use foam as the main material for our structure we want to use prototype 1 to get an idea for the strength, durability, and ability to hold water. To keep the test cost efficient, we have acquired some scrap pieces of the foam that we plan to use as well as various types of glue.

We will do three main tests for the structural system. First, we will cut up small blocks of the foam and try a butt joint with three different kinds of glue. Gorilla glue original, clear gorilla, glue and another type of glue that will be determined later. We will then break the joints to see the strength of the joint (take note if the joint fails at the glue or at the foam. We will then select a glue to use based on the strength and easy to work with. After the first test using the selected glue, we will make 2 boxes out of the foam one we will coat with a protective spray. We will then fill both boxes with water to see if they are able to hold the water without leaking. If they do leak, we will try different sealants or look for a different solution. To pass the water test the boxes must be able to hold the water for 2 days without leaking (note: we will monitor the boxes for longer than two days, but two days will give us an idea of the waterproofness of the boxes.

Delivery system

For the delivery system we are wanting to see if the water can cover the entire root system. We plan to make a panel out of some scrap foam to replicate on the side of the hexagon units. We will then 3D print a cup for the plants to replicate the roots system with yarn. Next, we will pour water down the side of the panel to replicate the pump. During the test, we will check the water flow through the cups and the coverage of water on the roots of the system.

Prototype 2

Prototype 2 will be for refining the overall design to prepare for the execution of the third prototype. To do this we will do the necessary calculations to determine the ideal material thickness of walls, lids, etc.

After determining the wall thickness and overall dimensions of the pieces, we will use the CEED laser cutter to cut the necessary templates for cutting out the foam. Then we will test the templates and building techniques by making one of the units to identify potential problems. The main tools that we plan on using for the construction of the project are table saw, utility knife, and glue, tape (for clamping), and sandpaper.

The pump will be tested by submerging the pump into a bucket of water and adding a 7ft pipe to the pump. We will then test the flow rate of which the pump is able to pump water to the top of the pipe. Also, we will test the solenoids with the pump to see if the pump is able to generate enough pressure to open and close the solenoid.

For the nutrient system we will add the sensors to the prototype 1 circuit. We will update the circuit design as necessary. We will run the system to simulate high pH levels, low water levels, and see if the lighting is properly controlled by the photosensor. All results will be documented and detailed instructions laid out how to replicate the circuit which will be used for the MakerRepo folder. All results of the prototype will be documented and necessary revisions will be noted.

Prototype 3

For prototype 3 we will make the entire unit and integrate the top unit and nutrient system from prototype 2 making necessary changes. We will plan to finish construction early to allow time for testing and modifications to the final unit. All prototyping materials will be replaced for product materials (such as replacing breadboard for circuit board.

Aesthetics will be added to the structure through sanding, painting, and adding logos and labels. If time will we consider including some of the additional aesthetics outlined in the Aesthetics and Finishing at the end of the document?

In addition, we plan to write an instruction manual for the user to allow for easy operation of the prototype. The instruction manual will include setup instructions, pH and nutrient charts, and programing instructions.

Finally, presentation props for design day will be made and a general presentation of the product will be outlined. Some of the props could include posters, plants to put in the hydroponic, etc. Must stay within budget.

Revised Budget

We revised the budget that we made for deliverable E due to the cost of materials and a change in design. The budget in deliverable E we planned to use plexiglass for the construction of the prototype. However, we were only able to afford plexiglass that was 3mm thick which would be unsuitable for strength and construction of the prototype. After a review of our list of materials we changed the plexiglass to a XPS foam board. This change allowed for more structural stability and cut the cost of structural material in half. Thus, we changed the budget to include XPS foam rather than plexiglass.

Prototype 1 Results and Conclusions

Nutrient System Test

By following the wiring diagram below excluding the sensors we wired the mega arduino to the 8-channel relay and 3.5 TFT touch screen. For the code the mcufreind, Adafruit, and TouchScreen libraries from arduino's public domain were used. Upon running the trial code, the results were promising. The touch screen responded appropriately to the user's touch and the display was relatively clear.

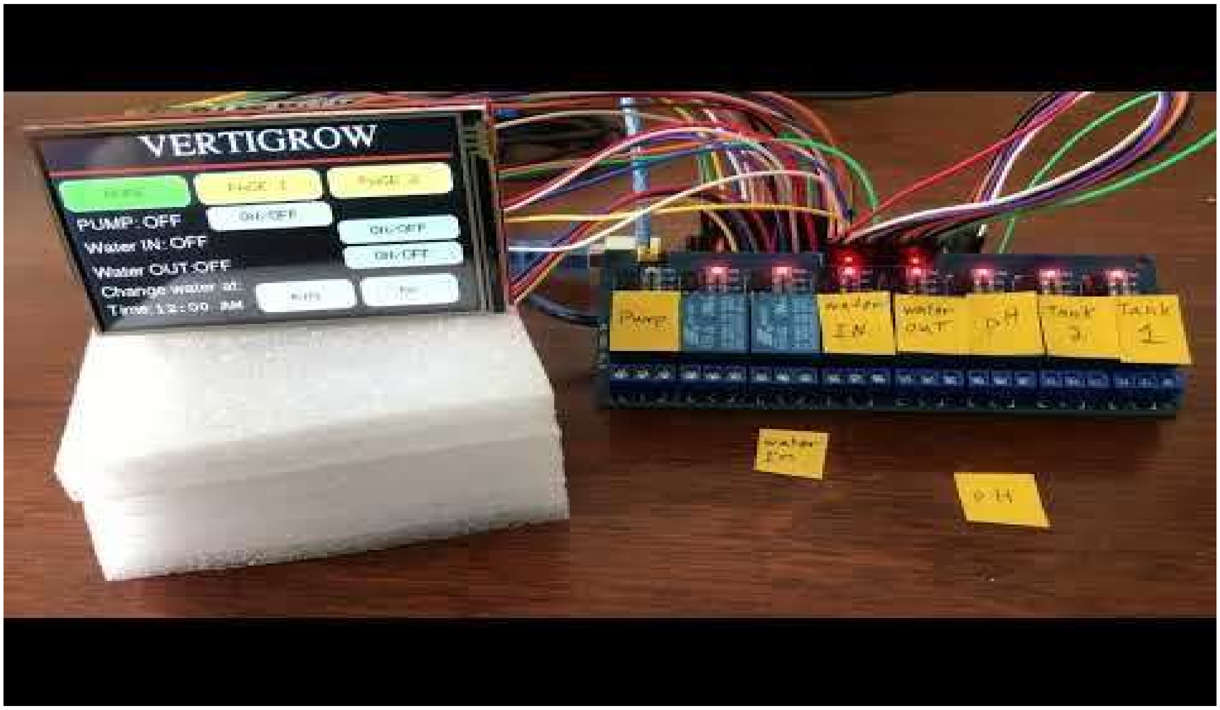
The clock function for the code was tested by running the electronic system overnight. After debugging the code, the clock keeps perfect time for 24 hours and it was successful at changing the day of the week.

Next, all off and on buttons were tested to see if the screen changed and the relay would respond appropriately. Also, for important buttons such as turning the pump on and off a warning screen was to be displayed to avoid users accidentally turning off the pump. After testing, all the buttons responded appropriately changing the screen and relay.

Then, we tested the system's ability to empty and fill the tank based on the clock-timer. We did this by modifying the pre-set settings of the system to trick it into thinking it was time to change the water. Then we observed if the appropriate relays were tripped, and all the delays worked. After completing the test 3 times we concluded the changing water sequence was activated according to the pre-set time. Note: this test is not included in the video.

Test video 1: Nutrient System

Click to follow link:
https://www.youtube.com/watch?v=vX-vEAgLK2w

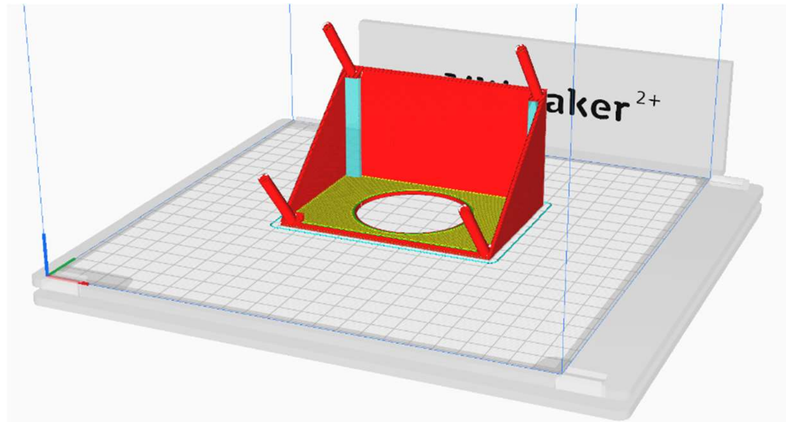


After compiling the code for the touch screen the code took up 21 percent of the arduino's memory (approximately 1500 lines of code). Based on this once we are done with all the code the code will only take up 30-35 percent of the arduino's memory leaving plenty of memory to ensure the running speed of the arduino.

Structural and Delivery System Test

For Prototype 1, we used rigid foam to create a model of a single panel of one grow unit in our system. We used 3D printed cups for the part that will hold the plant and built the panel and the part responsible for holding the cup from rigid foam. The entire process took 3 hours for 3 cup holders, meaning a rate of 1 assembled cup per hour. With 36 cups for the whole system, creating only the individual panels would require 36 hours of work. This is not plausible, so we revised our design to include 3D printer cup holders and cups. This will make the production process significantly easier taking approximately 2 hours to print one cup holder.

Figure 9: 3D Printed Cup Holder



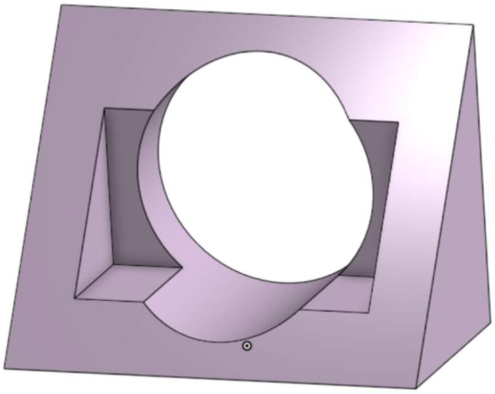


Figure 8: Original Cup Holder

In testing glues, we found that super glue dissolved the foam making it an unsuitable choice of glue. For wood glue the test joints broke at the joint due to a lack of strength from the wood glue. The original gorilla glue was stronger than the wood glue however the expanding capabilities of the glue caused the joints to expand and become unflushed with the surface. Finally, there was clear gorilla glue that had reasonable joint strength and did not expand like the original gorilla glue. Since we were not totally satisfied by this we decided to do some more research on what glues were good at gluing foam. Upon doing some research we found a glue called foam fusion which creates a thermal bond between the two pieces of foam. While we were unable to get our hands on this glue for prototype 1 based on our research, foam fusion is the strongest glue available for joining foam together. We will be testing this glue in prototype 2.

After completing the one panel of side units we took the 3D printed plant cups and used yarn to simulate the roots coming out of the cups. We then placed the cups in the panel. Next, we poured water on the top of the panel to simulate water pouring down the sides. We were primarily interested in seeing if the water was diverted by the plant cups and roots. After completing the test we were satisfied that water flowed properly down the sides of the panel covering each plant. In fact, from the test we conducted we observed that the roots will actually assist the water flow straight down the sides without diverting. The test video 2 demonstrates this test.

Figure 10: Cup with Yarn

Figure 11: Back View Unit Panel

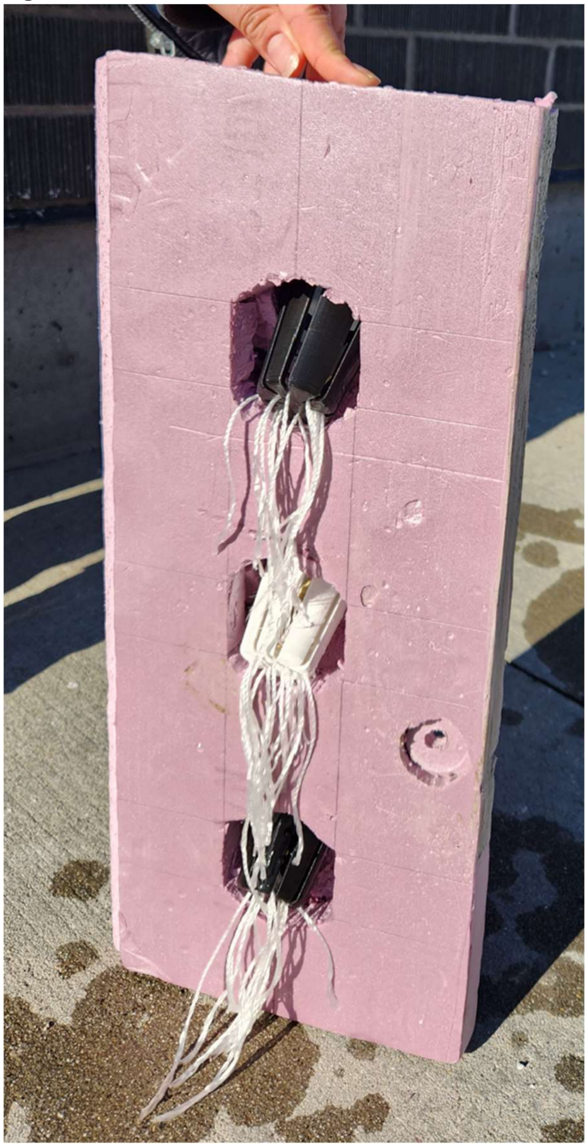


Figure 12: Front View Unit Panel

Test video 2: Structural and Delivery System

Click to follow link:
https://www.youtube.com/shorts/6iZKRg8BHkg

Aesthetics and Finishing

Our goal is to incorporate an indigenous theme for the non-profit organizations. We are hoping to create one fluent image on the hydroponic. To execute this, we would use one image and paint it around the outside of the hydroponic system. We have researched multiple different First Nations art pieces which speaks highly of the tradition. The first design is titled “shaman and Disciples” by Norval Morrisseau, and this design is complex and would only be used as a template if we have a large amount of time. A problem with this art piece is it would need many different paint colours which would go over our budget. The second piece is much simpler to recreate an owl using only 5 colours. Our main priority is to make the hydroponic as clean looking as possible and with this art piece, it allows open space and a more fluent image. The materials necessary to complete this task would be using water-base acrylic or latex paint. We must avoid using spray paint as it corrodes the foams.

Simple:

Complex:

Conclusion

With so many different parts within our more abstract delivery design, it is important to address each problem that arises, but also to predict potential problems as we continue to move forwards in creating hands-on prototypes for our system. Our prototype 1 was an overall successful first step towards our finished hydroponic system. A rough test indicated that the flow of nutrient solution does flow relatively within the required bounds for which all 3 stacked plants are able to receive about the proper amount. We found that using foam in some parts of our design, specifically the cup holders, was unrealistic. However, we will still be building the faces of the unit from foam.

We were also able to design a fully functional nutrient electronic system using a touch- screen display, a mega Arduino and an 8- channel relay. This electronic system responds appropriately to the user's inputs and keeps perfect time. Finally, we successfully tested a single panel of a grow unit for water flow and distribution of water through the system. We will use the results we obtained in Prototype 1 to refine the overall design in Prototype 2. Specifically, we will begin to 3D print the cup holders that we will need, we will test the pump system for its vertical pumping capability and use of the solenoid valves, and we will connect the sensors to the nutrient electronic prototype system and simulate high pH levels, low water levels, and see if the lighting is properly controlled by the photosensor. We will also have to continue to refine and adjust the shape and delivery of the nutrient supply to the cups. The system still needs to be tested numerically on how much nutrient solution each plant cup is receiving specifically. Furthermore, testing will have to be done on the actual stacking of the units to determine how to narrow down and focus the fluid flow. Structurally, the foam fusion glue among other structural construction aspects will start to be tested as well as finalizing wall dimensions and other measurements, and the electronics of the system will continue to be troubleshooted and streamlined. We have been progressing well, but with the complexity of all the components, it is important to continue to focus and make sure we deliver on our promise of this versatile hydroponics system.