Prototype II and Customer Feedback

Genius Troop

Steven Dunbar

Jeffery Xia

Jean Paul Kazzi

Dora Kam

Neven Greguric

March 12, 2023

Abstract

This document outlines a plan for creating the second. The document includes covers the customer feedback received from prototype I. The document explains how the prototype 2 will be used to test most critical systems of the design. Finally, the document summarized the results of the design review and prototype II.

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Feedback From Client

The feedback from the client was primarily positive. We learned in the meeting that she changed our building location to her own house rather than the farm. She expressed excitement in our design and said that she is going to look after the hydroponic herself as it is more complex compared to the other hydroponics. She also mentioned that she was not experienced in using technology. However, after seeing our nutrient system display, she was confident that she could handle the programming of the system since it can be easily followed.
Based on the client's feedback, we will continue with execution of our design plans. The big takeaway from the meeting is we need to ensure that we keep the system as simple as possible without losing the functionality of the hydroponic. We will use this feedback as we modify the programing of the hydroponic system.

Results From Prototype I

In prototype one, we tested the nutrient system and the water flow distribution on the sides of the hydroponic. The nutrient system proved to be reliable and easy to program. We presented the nutrient system to a few peers and the clients; receiving positive feedbacks on how simple the system was to navigate. The overall feedback for the nutrient system was positive, explaining how the screen was easy to navigate and understand.

To test the water delivery for each plant, we built a section of one of the units and added the cup holders and cups. In the construction of the cup holders, we learned that making them out of foam was time-consuming and produced a bad product. Based on this fact, we later changed the design to have 3D-printed cup holders instead. After constructing the section out of foam, we ran water down the sides of the sections and the results were promising. The water did flow to the bottom of the structure hitting all the plants. However, some water did leak out of the front of the wall section. We were unsure if this water was due to the poor construction of the prototype or a design flaw. We acknowledge that this is our most critical subsystem, hence, deciding to replicate this test for prototype 2 but instead using the 3D printed parts.

Prototype II

Prototype II will test the water flow delivery to each plant. The basic setup of the prototype will be a foam board with the 3D printed cup holders and cups atta. We can then test the water flow down the sides like in prototype one. The main difference is the cup holders will be to scale and fully closed. We can then see if water still leaks out the front of the system. In addition, the prototype will allow us to see how easily it will be to construct the system. We will also test the CAD designs for 3D printing the cups and cup holders to see if there are any flaws in the design/programming. We also want the 3D designs to print as efficiently as possible since we

will need 36 cup holders and 36 cups. This can be done by increasing the number of things being printed at a time for each individual printer.
We will accomplish this prototype before Mar 8 in order that we can use it as a demo to show the client. The prototype will be successful if the water flows down the sides without leaking, and the model is easy to construct. The 3D designs will good once a prototype has been completed that satisfies the strength requirement and prints in an efficient amount of time.

Calculations

I. Pump:

Assumptions for calculations:

- Steady-state flow
- Incompressible, Newtonian fluid
- No change in velocity ($V_f = V_i$)
- Pump introduces no additional friction loss
- Flow is unidirectional, upwards (no angles)

Given:

- Maximum volumetric flow Q_{max} = 3000 L/h
- Volumetric flow used Q = 2000 L/h
- Maximum power output of pump W_{max} = 24 W
- Diameter of PVC pipe D_{pipe} = 0.5 in = 0.01295 m
- Pressure at top of pipe $P_2 = P_{atm}$ = 101325 Pa
- Height of piping h = 2 m
- Dynamic viscosity of water μ = 0.001 Pa.s
- Density of water = 1000 kg/m^3
- ε = 0.000001524 m

Calculations:

- Apply Bernouilli's equation:

$$\frac{dW_{n1}F_1}{dm} = \frac{P_2 - P_1}{\rho} + g(h) + \frac{v_2^2 - v_1^2}{2} + F$$
$$\frac{dW_{n1}F_1}{dm} = \frac{P_{atm} - P_{atm} + \rho g h}{\rho} + g(h) + 0 + F$$
$$\frac{dW_{n1}F_1}{dm} = F$$

- Reynolds number calculation to determine type of flow:

$$Re = \frac{vD\rho}{\mu} = 55\ 697 > 4000\ \left(turbulent\ flow\right)$$

- Friction factor calculation:

[Equation]

- Friction calculation:

$$F = \frac{2fv^2h}{D} = 31.57\ N$$

- Work (power) calculation:

$$W = \rho Q F = 17.54\ W < 24\ W\ (\max)$$

II. pH:

Assumptions for calculations:

- Diprotic acid behaves as monoprotic acid
- Initial pH = 7

Given:

- Acid constant of phosphoric acid K_{a1} = 7.2E-3
- Acid constant of dihydrogen phosphate K_{a2} = 6.3E-8
- Volume solution = 25 L
- Concentration buffer = 0.01 M

Calculations:

- Apply Henderson-Hasselbalch equation (initial):

$$pH = pKa + \log\left(\frac{[A^-]}{[HA]}\right)$$
$$6.50 = 2.15 + \log\left(\frac{[A^-]}{[HA]}\right)$$
$$\frac{10^{-6.5} - 10^{-7}}{F - 10^{-6.5} - 10^{-7}} = 10^{6.50-2.15}$$
$$F = 2.16 \times 10^{-7} M$$

Volume of buffer to be added (initial):

$$C_{sol}V_{sol} = C_{buffer}V_{buffer}$$
$$V_{buffer} = 5.40 \times 10^{-4}\ L$$

- Apply Henderson-Hasselbalch equation (desired pH):

$$pH = pKa + \log\left(\frac{[A^-]}{[HA]}\right)$$

$$6.50 = 2.15 + \log\left(\frac{[A^-]}{[HA]}\right)$$

$$\frac{[A^-]}{[HA]} = \frac{[H_2PO_4^-]}{[H_3PO_4]} = 22\ 387$$

$$[H_3PO_4] = 1.41 \times 10^{-11} M$$

- Calculations to determine amount to be added based on current pH:

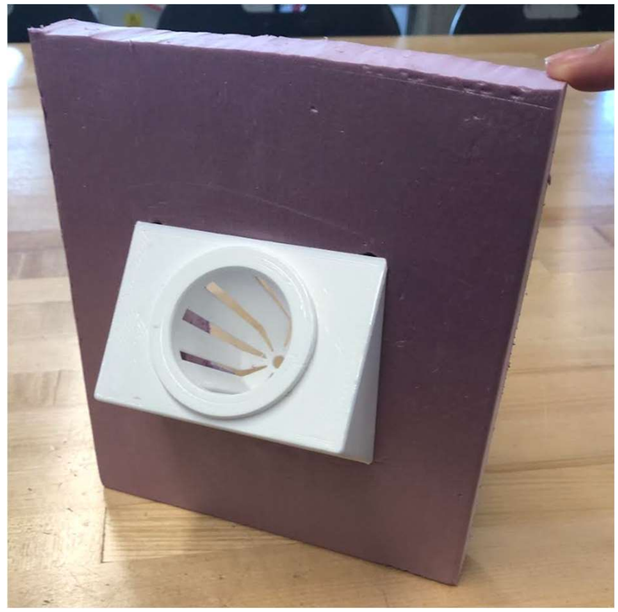
$$assume\ pH = 8$$

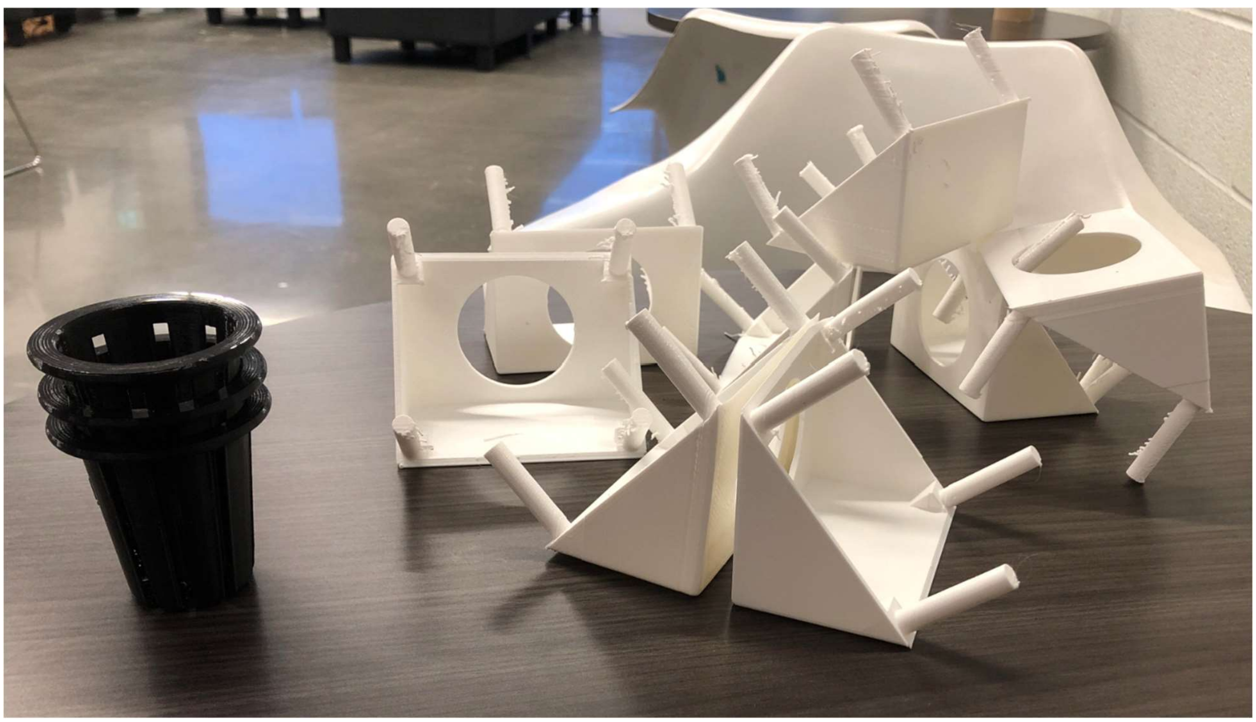
$$[H^+] = 10^{-8} = [H_2PO_4^-]$$

$$[H_3PO_4] = \frac{[H_2PO_4^-]}{22\ 387} = 4.467 \times 10^{-13} M$$

Prototype II Results

With our newly updated prototype, we have changed the structural design for the cup holders. In prototype one, the cup holders were made from foam, and we have found multiple problems with this method. When it came to the construction of our prototype there were issues with the cleanness of cutting, it was time consuming, and was unable to hold together for very long. As for aesthetics wise, the result looked sloppy and did not represent the time and effort we had put into creating it. For our prototype two, we have decided that 3D-printing our cup holders is aesthetically pleasing and it is able to withstand a heavier load on the angle it was placed on. The design of the cup holder has 4 structure poles that are placed on the back. This is to help attach the cup holders to the foam walls and create a stronger bonding joint. We have calculated that we would need 36 cup holders in white and 36 cups in black to be able to complete our hydroponic.





Prototyping Plan

The following table outlines the plan for the completion of prototype three.

Test ID	Test Objective (why)	Description of Prototype used and of basic test method (what)	Description of results to be recorded and how these results will be used (how)	Estimated test duration and planned start date (when)
1	Test structural strength	We will make a one complete unit and test to see if it can handle various strength tests.	The results will be recorded by testing the deflection of joints. If the joints our not strong enough changes to the design will be made.	Start on March 15 and complete on March 22.
2	Test the electronic components.	Install the electronics into the base of the box and connect the power supply.	Test to see if all the electronics are working properly.	Start on March 15 to March 25
3	Water delivery to plants	Fill the base with water and stack the units on the base. Run the pump and check to see if every thing is getting water.	Test by sticking your hand through the holes to determine if you feel the water running down.	March 22 to March 29
4	Unity of the system	Run the system through a series of test to ensure that the three systems work in unity together.	Trigger the change water sequence on the system and test outlets and sensors.	March 22 to March 29

Aesthetic and Finishing

After reviewing prototype one aesthetic design and methods, we have decided in some modifications. As a group, we thought painting the hydroponic could negatively affect our overall aesthetic because of the time we would have to spend and the lack of time we have, which would note a good outcome. Along with the budget, buying multiple unnecessary colour paint/materials would exceed our 750$ spending. As a solution, we chose laser cutting the wooden base in a design to make the hydroponic be cost efficient and look professional. Overall, our goal has stayed the same as the first prototype which is to incorporate an indigenous theme for the non-profit organizations and have a flowing image.

Example:

Conclusion

It is important to address issues that arise in each step of the project and predict potential problems. Our prototype two was an overall success and this is a step closer to our final hydroponic system. A rough test indicated that the flow of nutrient solution falls well down each root with no leakage from the foam wall. We have also calculated how many watts would be needed for the pump, and how much pH buffer would be added above. Our main change from prototype one is the cup holders as they have changed from foam to 3D-materiall and do not require a lot of f unnecessary effort. Structurally, they are stronger and aesthetically smoother.