Prototype III and Customer Feedback

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Abstract

This document outlines a plan for creating the third prototype. The document covers the customer feedback received from prototype 2. The document explains how the prototype 3 will be used to test critical systems of the design. Finally, the document summarized the results of the design review and prototype III.

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Feedback From Client

When we showed prototype II to the customer, she showed excitement that the cups were removable and could be detached from the cup holders easily. She also mentioned that our design looked to be durable over a long period of time. She showed great excitement for our project due to the number of plants it can hold/grow with minimal space required. A pleasant aesthetic feature that the client was really pleased with was that our hydroponic design and our construction greenhouse design are both in a matching hexagon shape style. After presenting our electronic system to the client, she concluded that she likes that the system was easily programed and did not find an issue in using the electronic system herself. This was great news to hear as she had originally expressed concern over not being overly confident with working with electronics.

Results From Prototype I and Prototype II

Prototype I was mainly focusing on testing the water delivery system. Checking to see if water would be supplied to each of the individual plants. To test this, we made a panel of the unit so we could replicate the water flowing down the sides of the hydroponic. The test was a success, and we were happy to not change the design of our water delivery. Some issues in the construction of the prototype were that the cup holders were made from rigid foam which would not cut smoothy and make a mess. Also, it was time consuming cutting multiple different sized pieces of foam which most of these cuts required a 45-degree angle cut with a knife. In addition to these issues, cutting an even hole for the cups caused a lot of difficulties in accuracy. Overall, we decided that taking 3 hours to make 3 cup holders were not beneficial with our time and did not produce the desired aesthetic for our hydroponic.

In prototype II we tested the assembly of the units to see the structural integrity and ease of construction. Since we found problems with making the cup holders in prototype I, we changed our cup holder design from foam to 3D prints. For prototype II, we assembled one of the 3D printed cup holders into a piece of foam. The process was both easy, quick and produced strong waterproof cup holders. We found that we could use hot glue to secure the cup holders on the back of the foam. Once this was assembled, it was important that we caulked the sides to waterproof the cup holder. We were happy with the clean outcome of this test, which allowed us to further continue with the 3D printed cup holders.

Furthermore, we tested our 3D designs for two main features; strength and speed. Testing the strength was to ensure the prints were durable and the speed was a necessary component as we had to ensure they were completed in time for design day. We tried a variety of thicknesses and found that the 2.5 mm wall thickness with 10% infill was the ideal settings. In addition, we modified the 3D designs to allow us to print as many parts as possible on the 3D printer plate. As a results, we were able to print 6 cups or 4 cup holders at a time on a 3D printer.

Prototype III

For prototype III, our goal was to test the strength of one unit in our design. Mainly observing if the unit could hold the weight of the other stackable units and plants. To complete this, we made one unit and tested the glue joints, cup holders, paint durability, and aesthetic of the overall design. Before starting the 30-degree angle cuts for our individual foam unit and base, we ran into an equipment issue. We found that the table saw, which plays an important role in our process of construction, was not available in the stem building. This was a setback in our progress for the hydroponic and we spend the next couple of days trying to acquire another way to cut our materials safely. We tried using a circular saw but found that it was too powerful and cutting the foam with it was quite dangerous. After some searching, we found a small circular saw that only had a 2-inch blade which meant it was less powerful and easier to handle. With a safer method of producing clean 30-degree cuts on the foam, we were able to produce the cuts for all the sides in one unit. We then added the cup holders and secured them with hot glue in the back of the foam. Once the hot glue was dry, we used foam caulking to waterproof the seams to avoid any water leakage. Now that all the foam pieces were produced, we used a construction adhesive for the foam boards and glued each side together. Painters' tape held the pieces together in place while the glue dried. We used painters' tape instead of heavy-duty clamps simply because the clamps would disorient the shape of the hexagon we were trying to produce.

By making one of the units, we were able to test the functionality of the entire system. We could then test the water flow down the sides of the system and the sensors that relayed information back to the nutrient system.

Prototype III Results

From the construction of prototype III, we learned that it was hard to make a perfect hexagon due to the amount of error in the cuts and the glue. To fix this problem we decided to use a hexagon shaped object to test the alignment of our units and base to ensure that the project would be the right shape. Also, we found that the amount of glue that we need to each unit was significantly more than we had originally planned. Then, after checking on the finished unit the next day, we found that the glue had not fully dried. After re-reading the glue label, we found the cure time was larger than 24 hr. This meant that we could not leave the gluing to the last minute and that we should ideally get all the gluing done a week before design day.

The final product of prototype III was successful as we ended up with a design that looked aesthetically pleasing and functioned properly. We were able to get the unit to resemble the shape of a proper hexagon by making use of the parallel angels and measurements on the CAD design. We tested our paint on the foam to see if the foam would be melted by the paint.

thankfully, the foam was not eaten by the paint so were able to apply the primer to the foam before glue the units together.

Figure 1: Prototype III dry fit

Figure 2: Prototype III glued

Feedback

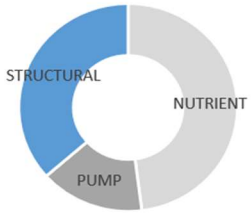
A large portion of our feedback that we received were positive. Some questions that had been asked are if the hydroponic system would be done on time, especially since we have roughly a week left. As a team we are not worried about the time required to finish the hydroponic since we have made significant progress, and we take time outside the lab class to continue constructing parts of the hydroponic. Another question was if the stackable units were too heavy; however, after prototype III testing, we concluded that the weight was not an issue since the units are very strong, stable and durable. During the progress of the individual foam pieces, some comments were made about the aesthetics of the foam because it was originally pink with words on them. We have decided to paint the foam all white to have a clean look which has been positive feedback from others.

Updated Bill of Materials

After purchasing the materials and beginning on the construction of the hydroponic we found that it was necessary to update the bill of materials to more accurately reflect the materials used and cost.

	TOTAL COST	TOTAL COST PER SYSTEM			ADDITIONAL COSTS
		NUTRIENT	PUMP	STRUCTURAL	
LOW EST	$ 525.51	$ 247.00	$ 83.03	$ 195.48	
HIGH EST	$ 596.50	$ 291.50	$ 91.00	$ 214.00	
AVERAGE	$ 561.01	$ 269.25	$ 87.02	$ 204.74	

BUDGET CAP	% VALUE
$ 500.00	112%



	COMPONENTS	QUANTITY	COST	SOLD	ACQUIRED	TOTAL $
NUTRIENT	*MEGA ARDUINO*	1	$ 30.00	HERE	☑	$ 30.00
	RELAY 8 CHANNEL BOARD	1	$ 11.00	HERE	☑	$ 11.00
	PERISTALTIC PUMP	3	$ 12.00	HERE	☑	$ 36.00
	SOLENOID 1/2 INCH	2	$ 15.00	HERE	☑	$ 30.00
	PH PROBE	1	$ 20.00	HERE	☑	$ 20.00
	BREAD BOARDS/CABLES	1	$ 18.00	HERE	☑	$ 18.00
	WATER LEVEL SENSOR LIQUID	1	$ 12.00	HERE	☑	$ 12.00
	3.2 INCH TFT TOUCHSCREEN	1	$ 30.00	HERE	☑	$ 30.00
	PHOTORESISTOR	1	$ 2.00		☑	$ 2.00
	POWER TOOL CORD, 6', 14, AWG, 15A/125V AC	1	$ 4.00	HERE	☑	$ 4.00
					☐	
	POWER CONVERTER: AC TO 12V DC	1	$ 37.00	HERE	☑	$ 37.00
	GFCI OUTLET	1	$ 24.00	HERE	☑	$ 24.00
	SILICON TUBE	1	$ 11.00	HERE	☑	$ 11.00
					TOTAL $	$ 265.00

	COMPONENTS	QUANTITY	COST	SOLD	ACQUIRED	TOTAL $
PUMP	*PUMP*	1	$ 37.00	HERE	☑	$ 37.00
	PVC TEE 3/4 INCH	1	$ 1.79	HERE	☑	$ 1.79
	PVC 3/4 INCH x 10 FT	1	$ 18.00	HERE	☑	$ 18.00
	FEMALE ADAPTER PVC 3/4 INCH	4	$ 1.73	HERE	☑	$ 6.92
	MALE ADAPTER PVC 3/4 INCH	3	$ 1.44	HERE	☑	$ 4.32
	PVC GLUE	1	$ 15.00	AVAILABLE	☑	$ 15.00
					TOTAL $	$ 83.03

	COMPONENTS	QUANTITY	COST	SOLD	ACQUIRED	TOTAL $
STRUCTURAL	*Clear Acrylic Sheet*	1			☑	
	Ridgid Foam 1 x 48 x 96 inch	1	$ 67.00	Here	☑	$ 67.00
	Chipboard 1/2 inch	1	$ 68.00		☑	$ 68.00
	Paint	1	$ 29.00	Here	☑	$ 29.00
	300 foam glue	4	$ 7.87		☑	$ 31.48
					TOTAL $	$ 195.48

Conclusion

It is essential to address issues that arises in each step of the project and predict potential issues. Our prototype III was an overall success, and this is a step closer to our final hydroponic system. A rough test indicated that the structure of the hydroponic units is strong enough to withstand the heavy load that it would need to carry from the plants. We have significantly progressed in our hydroponic and our final steps would be to assemble all our individual pieces together including the electronics, pumps and piping.