Report: Growing Futures - Hydroponic System Design

Jamie Burnett(300018035),
Nam Dao(300026099),
Adrian Martini(300021174)
Ebaad-ur-Rehman(8721476)
Sabyasachi Mitra(300005222)
GNG 1103 C-7
April 16, 2018

Executive Summary

Abstract

This project is dedicated to study and apply the design concept introduced in this course. This report will be covering a brief overview of the hypotonic system, client's needs, information given and possible solution for the design. Each prototype will be analysed individually, based on the basic ideas, key concepts and functionality. Three prototypes will also be compared with the requirement during testing for each stage. Lastly this report will cover possible sources of error that could have been encountered during the project and how to improve this project in the future.

Contents

List of Figures

Introduction

The hydroponics project was based around the idea and needs of the *Growing Futures* business, in which public school students use a variety of hydroponics systems to grow produce. The Client team presented a need for an improved system as theirs were hard to maneuver and were not as productive as was needed for their business model. In addition the systems they owned cost a large amount of money per each unit. Thus they were in need of a cheaper more efficient model that would allow them to increase productivity.

They expressed several different requirements that had to be included on the final product. The most important requirements were the following; removable plant holders, small in size, strong structure, portable, adjustable lights, and a large water basin. All of the needs that were given, were based off of an aspect of their problems they were having for their current systems. Things such as the water tank emptying out over the weekend and the plants dying, to the lights burning the leaves of the plants because they were too close.

Our design plan was to make the system as self-sustaining as possible, from using gravity to help keep the plants wet to a pumping system that would refill the water basin at regular intervals. The design would also be made out of cheaper materials to help reduce cost. The plan included 24 plant holders, with each one being removable from the system.

Initial Research

To begin the project we performed background research to understand how the unit is generally constructed to visualize what our product was to become. We sifted through many concepts of hydroponics units to gather as much information as possible and to open our minds to unordinary possibilities. Many units we discovered were being sold from large companies at expensive prices. This prompted us to research Do It Yourself websites to analyze how people used cheap and unorthodox materials to construct their unit. Another product of our research was the understanding of how to make a hydroponics unit visually appealing and marketable; this research also aided in making our unit simple to understand, easy to construct, and aesthetically pleasing. Another aspect of our research was researching how to make the hydroponics system automated, so that the clients do not need to manually refill any water basins. Weight sensors, laser sensors, and apps were all researched and considered but found to be too expensive, which motivated us to find our solution of using incremental periods of time programmed into a timer that turns the water pumps on or off. This form of automation is far more simple and cost effective than the other solutions being considered. Overall, our initial research helped create brainstorming ideas for our model and determine how we were to make our system automatic.

The Clients

The group that expressed their interest in creating a new hydroponics system was the *Growing Futures* Company based out of Ottawa. They are a small scale produce company that operates in a school setting. Its main objective is to help educate the student participants on good growing practices for the future, as well as teamwork and communication skills. The secondary objective of these clients is to produce vegetables and sell to local markets to raise funds for the team and help maintain their current hydroponics systems.

Customer needs

The customer was in need of an indoor hydroponics unit that improves upon their current design. The clients were experiencing issues with the water being inconsistently circulated, the main tank requiring regular refilling, transporting the unit, and accessing all areas of the unit. After experiencing these issues the customer desired to improve upon the water dispersal system,

main tank capacity, adjustable lighting, portability, modularity, and price. The customer also wanted new ideas implemented into the design, including a pH sensor, backup water supply and lights, and an app that allows one to control the water dispersal system from anywhere. Along with the many improvements and new aspects to the unit, it must also be structurally sound and safe for child use.

Prioritization

During the meeting with the client, they expressed several different key aspects that need to be included in the final project. The following table is a list of all of the needs and are ranked by level of importance.

Needs Identification Table

	Category	**Importance**
Strength and support	Structure	1
Accurate water dispersal system	Water/structure	2
Main Water Tank Capacity	Structure	3
Adjustable lights	Structure/lighting	4
Price	Cost	5
pH indicator	Water/structure	6
Easy for kids to use/ setup	Structure	7
Backup water tank	Water/structure	8
Portable	Transportation	9
Backup lighting	Lighting	10
More efficient cell removal and replacement system	Structure	11
compact	structure	12
20 or more plant cells	Structure	13

Area to display branding	Structure	14
App	Network	15

Problem Statement

The problem statement was based off of the clients' needs and wants from the first interviews held in class. It had to cover as many needs as possible as well as a proposed solution that the creator will be striving to achieve. The following problem statement was created by group C-7 for this project:

> To design a new hydroponics system that they will use in tandem with their current systems. This system will be used in an elementary school setting and thus must be accessible and easy to maneuver. They are looking for a cheap hydroponics system that is easy to move and handle, is compact but efficient in producing and maintaining its crop while also having more than 20 cells, and has an area to display branding for the company. In addition the client is looking for an app that can notify the owners of when the water is low or there is a change in pH.

Original Ideas

During our brainstorming period, the team had many ideas. Combining all the ideas together, we were able to come up with 2 final ideas.

Idea one

One idea was to have several pipes parallel to each other, vertically. Each pipe would contain around 7 plants and each side would have 4 pipes. In total, it would carry around 56 plants. The water would fall from the top between where the roots would be able to get their water. The dimension was 5 ft in length, 2 ft width, and 6 ft in height.

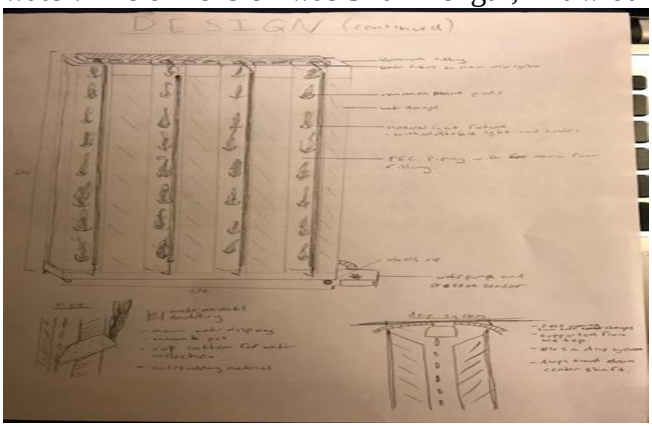

Figure 1

Idea two

Our second idea, we were more keen on. The concept would be really similar to the first idea but instead of vertical units it would have shelves. Each shelf contains 2 pipes. And there are 4 shelves and a tank at the bottom. The dimensions would be, 4 ft in length, 2 ft in width, and

6.5 ft in height, with 5 plants per pipe. In total, there would be 40 plants in total. The pump would bring the water to the top and the water would then be divided evenly to both pipes. Gravity, would then make the water go back to the tank. The brand name would be at the bottom. We ended up choosing this idea as it was favoured by the clients. Picture of the design is below.

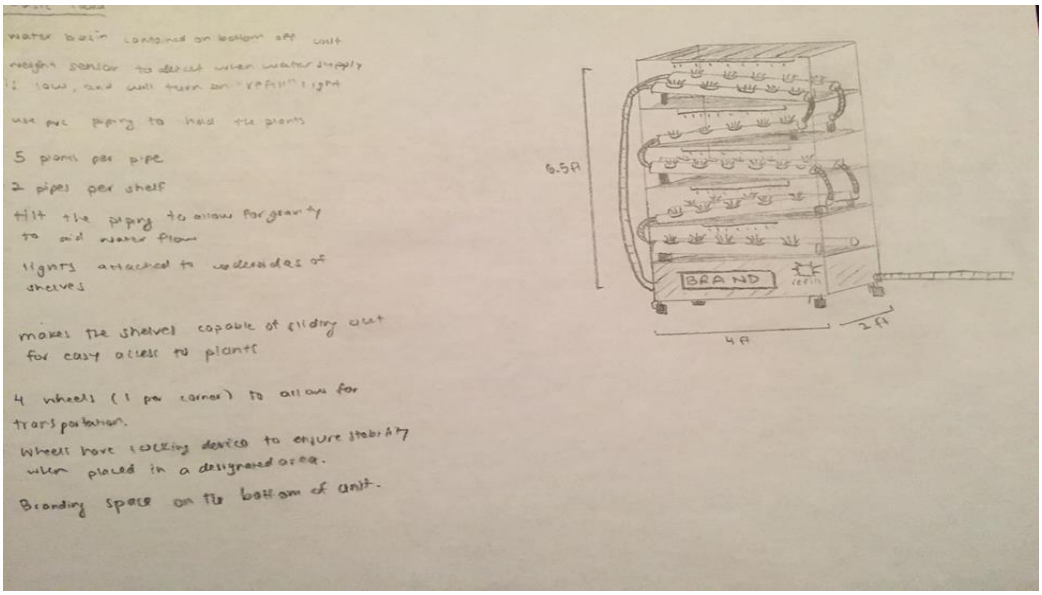

Figure 2

Prototype 1

Basic Idea

The aim for this prototype was to get a miniature version of the final prototype. As it was the first prototype, the overall goal was to show the basic structure of the hydroponic system. We were figuring out the schedules and tasks for each team member.. We kept making minor changes day by day. The prototype was constructed during the one of the lab sessions. This prototype was presented to the clients explaining the aim of how the prototype will work. They were impressed with the idea and they were very clear with the goal we are trying to achieve. The frame of prototype one was made out of cardboard.

Key Components

Components	**Analysis**
Lighting	Lighting was demonstrated with the white tape and we were planning to have it under every shelve. It would provide enough lighting to the plants. We were planning to use LED lights as they will provide enough frequency for the plant's photosynthesis function and would very long lasting.
Plant Pipes	The pipes were demonstrated by the red straws. We planned to have 5 plants per pipe. The materials we were planning to use for the plants was PVC pipes as it is durable, long lasting, and overtime, it will not release any plastic toxins.

Shelving	In the picture, the middle shelf is suppose to be rotated 180 degrees. The shelf is suppose to support the pipes to make the structure of the hydroponic system stable. Due to the placement of the shelves, it would allow the water go to back down to the tank with gravity. Cardboard
Water tank	The water tank is at the bottom of the system. The pump inside the tank would take to the water to the top of the system and then the water would come back to the tank due to the magic of gravity.
Branding	Branding was planned to be places on the side of the water tank. There is a lot of space is the branding can be as big as the company desires..

Figure 3

Functionality

The aim of this prototype was just from looking at the miniature version of the prototype, how the final product will run. The prototype perfectly suited our goal of an accurate representation of our final product, and showed all of the main subsystems that would be used in the later deliverables. All materials used for this prototype were from the maker lab, and more material preparation could have been done beforehand to improve results. The group and the clients were satisfied with the first prototype and decided to stick to this idea.

Prototype 2

Basic Idea

The basis of this prototype was to create the most important subsystem of the final prototype, and demonstrate that it would function as intended. The system chosen was the water and pump system. The key components that were included in this prototype were the tubing, tub and water pump. The pump had to be able to pump the water 5.5 feet up so that it can reach the top of the system. In addition the second prototype built off of our basic idea with the assembly of the pump system to the water reservoir. With the requirements being that the pump must be powerful enough to transport water 5.5 feet in the air.The secondary reasoning for the second prototype was to investigate how implementing timers will affect the pump and water flow in and out of the system

Feedback and Q&A from Clients

- Clients loved our automation, thought it was innovative and unique
- Questioned if the materials were safe for plant interaction, for which we assured them the materials we will be using will have no negative effects on the plants
- Overall the clients were satisfied with the concept

Key Components

Component	Critical Analysis
Hose	The hose will be connected to the water pump at the bottom of the structure and the cup holder to transfer water to the plants in the cups. The hose made of plastic therefore, it's easy to setup and flexible it won't break or ripped during setting up like other materials. The hose also does not contain any harmful chemical to the plant or human.
Tub	The tub will be at the bottom of the structure to hold water and supply it for the entire system. The Tub will be 3x2 ft to hold enough water for many days without refilling. Also the tub will be made of hard plastic since plastic is durable and won't rust like other materials which can harm the plants.
Water Pump	The small water pump will be attached at the bottom of the tub. The pump transport water in the tub through the tube to the top of the system where water will flow down and watering the plants. The water pump will also be connected with a timer. The timer will turn the water pump on and off automatically periodically.

Figure 4

Functionality

The completion of this prototype allowed for the continuation of research and development. With the success of the testing for this stage the most important subsystem is completed and will need to be tested once installed into the completed system. The results from this prototype were recorded as a success or failure based on the stated requirements made before its completion.

The only dependency for the testing was the shipping time for the material. Due to long shipping times the materials arrived on late, meaning that the overall test and construction could not take place until that day the next meeting after they arrived.

For this prototype the objective was reached through objectively testing if the pump was able to transport the water. The pump was connected to the reservoir and held the tubing to which it was held 5 feet in the air. The pump was able to get the water to that height and come back down successfully.

The timers did allow the system to become fully automated and user friendly. These timers were reliable and able to be connected to the prototype seamlessly. The timers for this model however had the wrong components shipped to properly install them and thus were not fully installed until prototype 3.

Prototype 3

Basic Idea

For the final prototype the basic idea was to create the most accurate model of our design as possible. It would have all of the main components including, tubing, plant holders, water integration, and structure. The piping would be sealed by a water resistant caulking. In addition 4 individual plant cups will be inside each PVC pipe.

Feedback and Q&A from clients
-The clients liked the tubing system due to the lack of dripping and direct contact with the planting pods
-It was also noted that the height was just above where they would have liked it to be because it is hard for the smallest of the clients to reach the top planter pods.
-In addition they expressed concern for the tubing transitions. They may leak and have not been entirely water ceiled due to lack of funds
-The clients did however like the removal pods, and the stated that the structure was more than sturdy enough to be handled by the children, and be safely moved.

Key Components

Critical Analysis of Components	
Components	**Analysis**
The tubing	1 long tube will be attach to the water pump in the water tank then connect to the highest pipe in our system in order to transport water from the water tank to our system. 6 shorter pieces of tube will be used to connect the pipes together to guide the water from the top back to the bottom of our system.
Plant holders	The cups will be holding the plants. The cups will also be made of plastic. 4 cups will be installed in the circular holes on top of each pipes which make a total of 24 cups for the plants since we have 6 pipes in total. At the bottom of each cups there are 6 holes so the plants can absorb water from the water system we made.
Water integration	Water will be transport from the bottom to the top by the water pump then create a water flow in each pipe and then through 6 holes under the cups the plants can absorb the water and grow without the help of soil.
Structure system	Our structure made mostly with wood and pvc therefore it won't harm the plants, long lasting and durable. We made a base to contain the water tank then use 4 long pieces of wood to support the whole system by connecting them with the base with the support of other pieces of wood. A drill and long nail was used to whole all the pieces together therefore it is very durable to be able to move around.

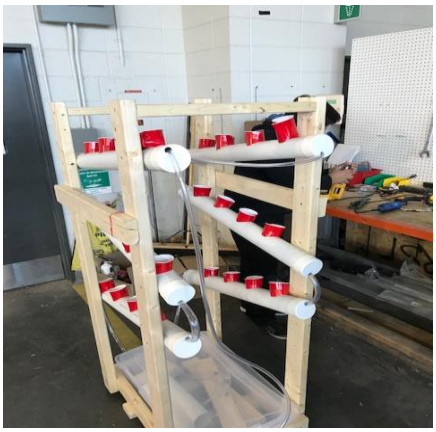

Figure 5

Functionality

This prototype was able to function for its intended purpose. After completing a second test with our pump to ensure it would reach the required height, the pump and piping were installed and tested. The water was able to make it all the way from the top of the system and then flow smoothly back down to the basin through the tubing which was what was intended in our design. As the water made its way down the system, it touched the bottom of every holder that was placed in the tubing. This again was another requirement for our testing as the plants would die if they were not able to reach the water at the bottom of the tubing.

The structure after completion stands at 5ft 9inches which is slightly above our intended length but was within the expected error of 5 inches. It will still be fully accessible to children and is sturdy enough to not topple when being moved or used. It has 3 main levels with each level containing 2 pipes and 4 plant holders. The pipes are drilled into the supports using 5 inch wood screws.

Time of Completion and Dependencies

This prototype took a total of 2 weeks to complete, with 8 hours being spent in the Brunsfield Center working on the actual prototype. There were a variety of factors that had to be taken into account when completing the final prototype including cost, materials and the building pattern needed to properly assemble the design.

In terms of materials some of the orders that were needed came from places out of country and thus took longer to arrive on campus. Thus some of the design were not able to be made until late into the two weeks limiting our time as the deadline approached. A second dependency was scheduling. Many of us are in different areas of engineering and thus being close to finals many had multiple midterms or large assignments due throughout the two weeks. This limited our amount of free time, and our ability to meet and construct the design. The building pattern was also a dependency as it cost us time. Certain components had to be made and measured before others could be constructed. For example the water basin had to be built before the piping could go in due to space. This slowed process slowed down our progress.

Conclusion

In conclusion the hydroponics system design for *Growing Futures* was a success with a working water and plant system. Most of the needs were met to an acceptable degree with only a

few components missing from the final design. The overall cost of the project was $151.69 which was approximately 50 dollars over the $100.00 budget.

Testing

Prototype 1	Aim of the prototype was to check that the challenges it was about to face would be successful. The clients and the group were satisfied with the design and the process of how everything works.
Prototype 2	We were able to test the water pump to make sure it able to transfer water to the top of our system (5.5ft). All the material used are safe for the plants
Prototype 3	We were able to make the whole system work in effectively and present it during design day

For future projects certain attributes or components can be worked on to improve the original design. Firstly the weight and size of the design can be reduced to allow easier access for children. In addition the wood can be replaced with stainless steel or another material to increase longevity and stability. Moreover materials from cheaper source/dumpster can be utilized to reduce the price as both the PVC and metals cost large amount of funds and hinder spending on other important materials. Stronger and more durable sealant could also be installed to prevent water from leaking at the bottom of the pipes. The final key component that can be added or improved on is the installation of a natural light bulb lighting system and wheels on the bottom to improve mobility.

Bibliography

1. Growingfutures. (n.d.). Retrieved April 16, 2018, from https://www.growingfutures.ca/
2. Bond, C. (2016, December 01). Hydroponics 101: A Back-to-basics Guide. Retrieved April 16, 2018, from https://www.maximumyield.com/hydroponics-101-a-back-to-basics-guide/2/1257
3. Bond, C. (2016, December 01). Hydroponics 101: A Back-to-basics Guide. Retrieved April 16, 2018, from https://www.maximumyield.com/hydroponics-101-a-back-to-basics-guide/2/1257