

Herb Reserve

GNG 1103

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Abstract:

The purpose of this project was to give us the chance to take the design learning skills we learned in class and implement it in a real-life opportunity. Growing Futures is an organization in schools that needed a design for their hydroponics wall system that is easily accessible for kids and is more cost effective. Growing futures came to us to help with their needs and give us the chance to design a system within the budget of \$100. We were given weekly tasks to complete all the necessary design steps to ensure we stay on top of things.

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Introduction

Growing Futures came to us looking for a better solution to their growing wall problem. This was a great opportunity for us Engineering students, because not only does it relate to our GNG1103 Design class, but to our future careers as Engineers. When Growing Futures first met with us, they gave us a list of basic needs and requirements to their vision of a solution to their problem. These included the aspect of portability, being easily accessible for younger children to interact with plants on the growing wall, and able to transport to and from different rooms in their schools. Plant capacity was another major concern, the kids wanted a solution to have over 20 plants yield. Branding was also a big part of Growing Futures focus, wanting branding to be incorporated on the overall solution. Through our design process we incorporated these needs as top priority from our first concept to the final prototype 3. We as a group designed and made a full-size prototype incorporating the needs of the client, including very high plant yield, branded with LED lighting, all in a portable wheeled cabinet style growing wall.

Main Body

Client Requirements:

Our Group broke down the needs of our client, Growing Futures and prioritized the most important needs that we focused on throughout the whole design process below.

Prioritized Needs:

1. Portability: smaller and lighter for easy access for kids, and ease of transport with wheels
2. Capacity: Needs to hold a minimum of 20 plants
3. Branding: Familiarize the community with their brand and their mission.

4. Large Reservoir: Plants always need to have water or they will die, critical to have enough water for the system to be operational
5. LED lights: Cheaper than current option. Also, LED's can be toggled, and are bright for Growing plants
6. Wall Communications: A way to relay information to the kids (ie water level). Possibly through an app
7. Door: protects from insects; maximizes light source; provides room for advertisement; requires ventilation of some sort

Problem Statement:

Growing futures needs a design for there hydroponics wall system that is easily accessible for kids and is more cost effective. Growing futures needs our help because they are struggling to find a design that is smaller in size, but still holds a similar amount of plant. Another problem is making it easier to transport around and for it to be elevator accessible. The kids at growing futures also expressed there needs for an improved reservoir because of the minimal amount of water the current one can hold. The reservoir also needs an app or timer to help with testing pH and for timing the amount of water being used. The final problem the kids at growing futures expressed to us is the way for their company's mission statement to be shown publicly on the design so people can read about what Growing Futures program is all about.

Design Criteria:

Benchmarking:

Our group considered the most important needs for our design and have represented these in the criteria below. Our main functional requirements included the portability aspect. Our biggest constraint was the weight factor and cost, after benchmarking we planned on a <50 lb

design, and have researched for the cheapest possible materials to buy. Lastly another vital piece that Sue and the kids from Growing Futures stressed was branding of Growing Futures, and we made that the priority for non-functional requirements.

Design Specifications	Relation (=,<,or>)	Value	Units	Verification Method
Functional Requirements				
Portability (wheels, able to come off wall)	=	yes		Design/ prototype
Lighting	=	yes	LED	prototype
Water reservoir	>=	60	Litres	prototype
Functional App to display key information (water level, time on)	=	no	NA	NA
Constraints				
Weight	<=	50	lbs	Analysis prototype
Plant Capacity	>=	20	Plants	prototype
Size and Dimensions	<	7	Feet tall	prototype
Cost	<=	100	\$	Prototype
Non - Functional Requirements				
Branding	=	yes		prototype

Table 1: Benchmarking Table

Concept Design:

Our group had many ideas for first designs for the growing wall. We compared different sketches of possible solutions and choose this concept below as a possible solution our team was going to continue with in future prototypes. This concept meets the needs of our client and has

details as to how the system would function. This was a good starting point in visualizing our overall solution, and lead to other design improvements further along in the process.

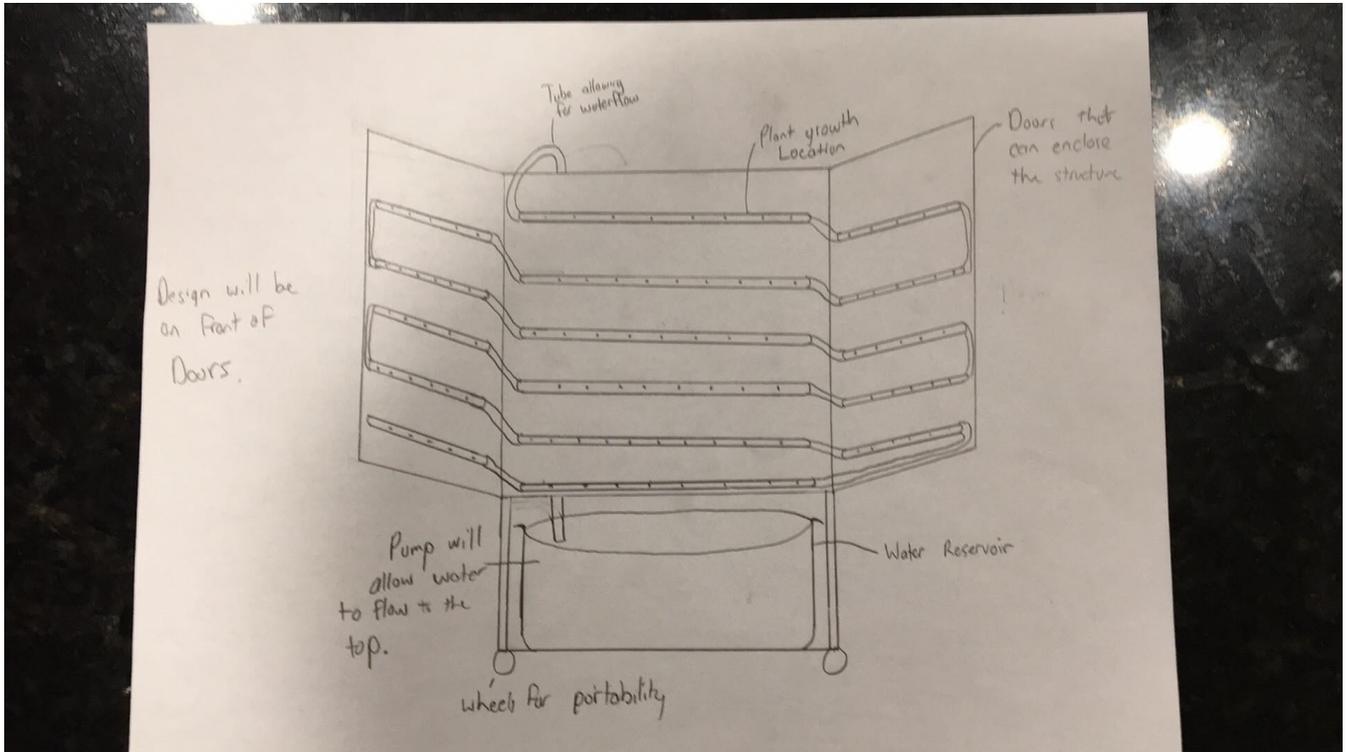


Figure 1: Concept Design sketch, including folding doors design with reservoir on bottom, wheels, and possible water distribution system

Prototype 1:

Why and How:

Our first prototype plan was to test basic design. This was a good starting point to test, as the design is crucial to an overall product. Our first prototype was a scaled model of our overall idea of a design. We as a group made a model of our idea out of household materials including cardboard and plastic tubing to showcase the basic design we are looking to capture in our final prototype. We measured the basic structural design of our concept. We used the materials

available in the makerspace to create our model. Cardboard was used to represent the walls and folding doors as well as the water reservoir and wheels on the base of our design. Paper clips were used to showcase hooks for the pipes of the plants to rest on. Straws were used to measure the growing pipes on the three growing walls. Our first prototype was successful at capturing our objective of an overall basic design. We as a group realized that we need to incorporate the distribution of the water from the reservoir onto the the folding doors with additional piping. Also we realized the needed spacing of each pipe of plants, and a criss-cross design needed for the plants to fit together when the doors are closed and the unit is transported.

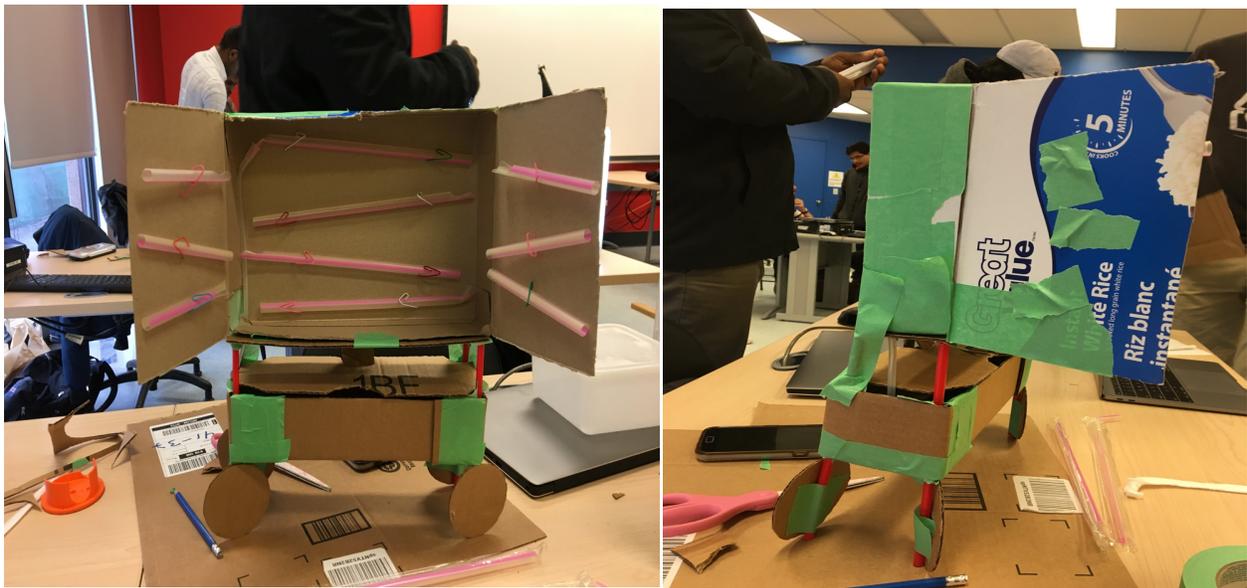


Figure 2: Prototype 1 Front and side views showing basic design

Prototype 2:

Why and How:

Our second prototypes objective was to test our water pump, and more specifically test the max height that can be pumped from the reservoir. The water pump is a crucial part of the overall grow wall, thus being a good second piece to test before our overall prototype 3. We tested how far the water could be pumped vertically, aiming for 4-5 feet to match our dimensions for the finished prototype 3. Specifically testing the pumps reliability and strength to determine whether our water distribution system was sufficient and provided a strong enough water flow. Unfortunately, changes to our system were required as the pump was clearly not strong enough to provide a constant flow to each of the plants. Also, we noticed an increased tubing size used for water distribution would create a much more efficient system.



Figure 3: Prototype 2: Mid-construction of back wall of design, with piping

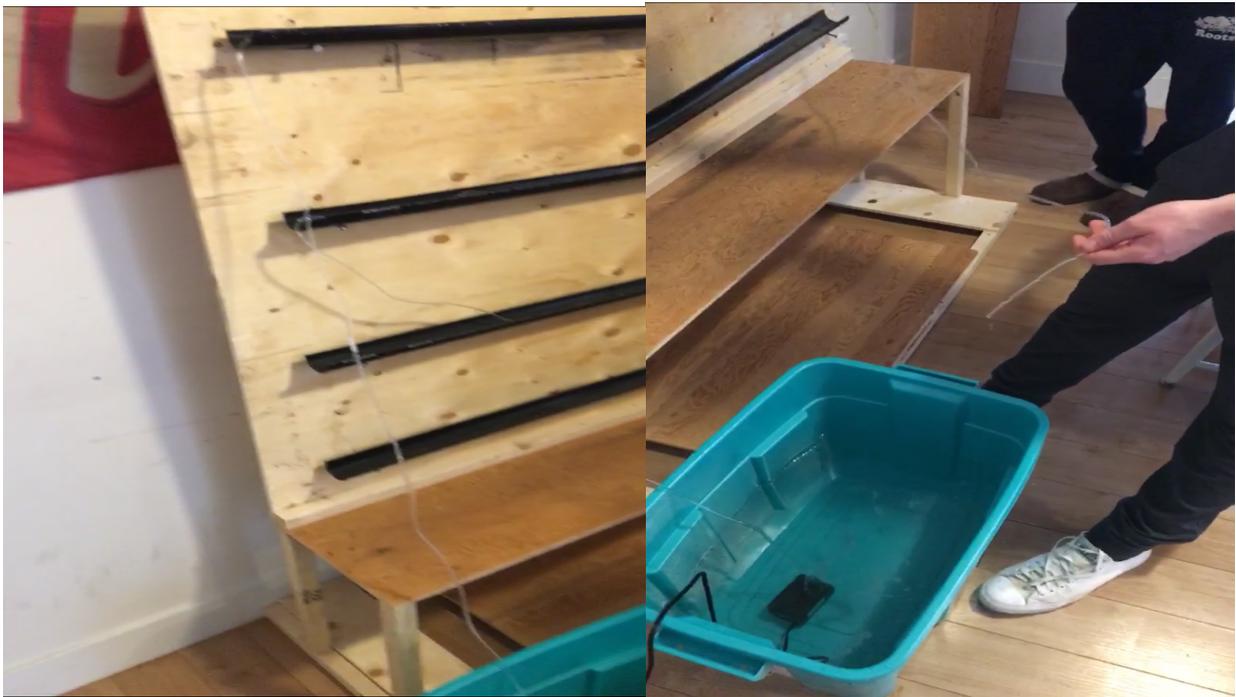


Figure 4: Prototype 2: Reservoir with pump being testing for water flow. Also the pump being tested for maximum water flow height.

Prototype 3:

Final Design:

Prototype 3 was a comprehensive, physical beta prototype; this is because it has been constructed and was used to test the complete functionality of the plant wall, to ensure reliability and to measure the consistency of the plant wall for long term use. From the prototype, we visualized the final product and analyzed it practically and constructively. With the 3rd prototype of our plant wall, we learned how functional it was (i.e. how well the wheels' work, how well the water distributes throughout the wall, how stable it is etc). From this prototype test, it was possible to find flaws in the water distribution, materials choices, build quality and overall functionality. From this we made the necessary changes to improve the design; whether that means changing materials, adding structural support or. For this test to be a success, prototype 3 would have to meet all the client's criteria and feedback as well as function properly and consistently. A failure would be the prototype's inability to meet any of the success criteria.

The test for prototype 3 checked the functionality of every part of the system. To start the test, we checked how well the wheels move around; when the wall is pushed around it should move as a unit and be sturdy from top to bottom. Next we inspected that the reservoir can hold the minimum volume required by our clients. Next, we tested how the water is distributed over periods of time. To test this, we will let the pump run and carry water for a long period of time and intermittently check how well the water is being distributed. We then inspected how structurally sound the prototype is; shake tests and moving across rougher terrain was sufficient. The information gathered was qualitative rather than quantitative so it was collected through

inspection and observation. Notes were taken on the flaws and ease of use issues noted from us as well as those mentioned from the client and then solutions were drafted.



Figure 5: Picture showing wheels on system.



Figure 6: Fully operational prototype 3 with all growing pipes, reservoir and tubing
Reservoir shown with 2 pumps working both the doors and back wall of the system.

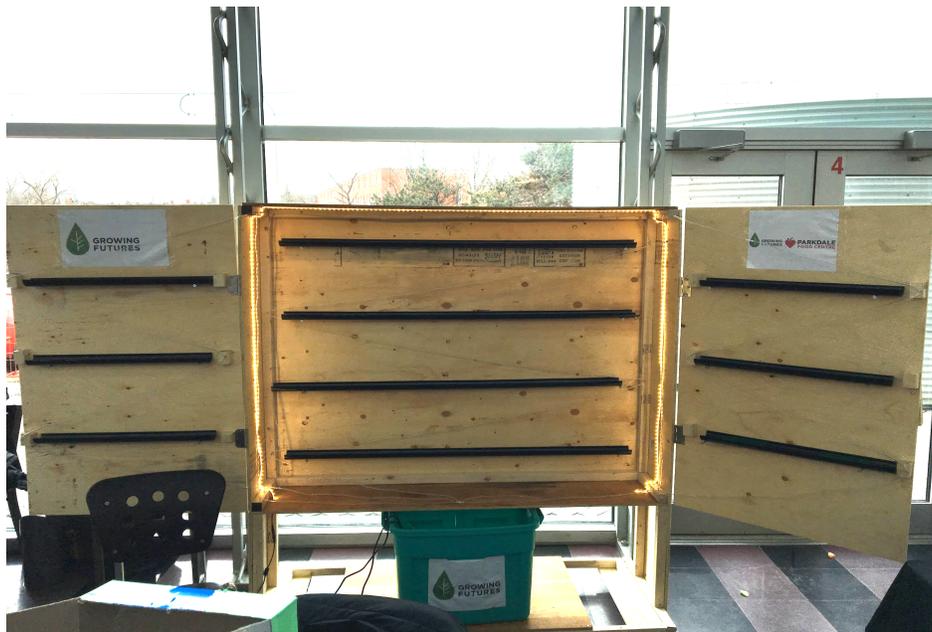


Figure 7: Full system with functioning LED lights around the perimeter of growing space.



Figure 8: Two functionable pumps and branding present.

Purchase Form:

Breakdown of all materials bought for our final system, total price \$229.33.

Product	Seller	Quantity	Price per unit	Total with tax
Water Pump	Amazon	1	\$12.99	\$14.68
PVC Pipes 2''x10'	Hardware Store Downtown Ottawa	2	\$33	\$38
Water Reservoir Sterilite 62 Liter Stadium Blue Latch Box	Walmart	1	\$10	\$11.3
LED Lights Strip "Susay Waterproof 5M strip"	Amazon	1	\$23	\$23.90
Flexible tubes	Amazon	2	\$3.49	\$7.89

50 feet				
Tubing	Amazon	1	\$9.00	\$10.17
Wheels Screws	Home Depot	4 2	\$7.45 \$2.97	\$40.39
Wood	Home Depot	2 Plywood 4 1" x 1"	\$30 \$2	\$68
Screws, and Hinges	Home Depot, Hardware store			\$15
TOTAL				\$ 229.33

Table 2: Purchase Form

Testing and Results:

Our first prototype was successful at capturing our objective of an overall basic design. We as a group realized that we needed to incorporate the distribution of the water from the reservoir onto the the folding doors with additional piping. Also, we realized the needed spacing of each pipe of plants, and a criss-cross design needed for the plants to fit together when the doors are closed and the unit is transported. We researched viable options for tubing and pumps and applied these for prototype 2.

Our second prototype was successful at providing insight to out water distribution system. After testing the pump, the water was able to flow to 5 feet vertically, but at a slow flow rate. The pump we bought was able to flow through our grow wall, but a more powerful one was to be a better solution. We as a group concluded a more powerful pump would be required to justify each row of grow pipes. A more powerful pump with tubing of an increased diameter will

allow us to flow more water to our required amount of plants. We applied these changes for our final prototype 3.

Prototype 3 formed our fully operational system according to the ideals of our group as well as majority of the ideals of the client. However, there was a couple problems, our system although fully operational, took on a larger than expected size, through building the overall prototype 3 we did not realize how large the system became. The growing space of our system was within our benchmarks and design criteria but the added space on the bottom for the reservoir added an extra 1-1 ½ feet of height making it less accessible for children. We as a group knew the implications of this added height and kept it in mind. Another minor problem was the power of the pump bring water throughout the whole system. After testing the system, water was only being carried to the 2 doors, therefore with the power of another pump it is guaranteed that the water was able to be carried throughout the whole system. Aside from the pump the doors were fully workable, the LED lights were functioning, the wheels maneuvered the grow wall and the overall theory of the system was working without any problems. Further improvements were the purchasing of an additional pump and added appropriate branding to our wall to meet the client's requests.

Conclusion

This report covers all the necessary procedures considered through our design process for our project, from the clients needs to the final prototype. Through this project we as a group learned what worked and what did not work with our design. For things that did not work we understood what sort of solution we needed to bring about in order to ensure that everything will

work. Even for the things that did work we can offer further solutions to further improve the system to ensure everything does run as smoothly as possible. This project also taught us useful design techniques such as the Gantt Chart which helps manage time and the processes that can be applied to almost any future applications that we will have in our lives. The project also gave us a sense of pride in work which helps motivate us to create more innovative creations like this or beyond.

Successes:

The main focus of this design was to sufficiently improve the setbacks of other hydroponic systems, noted by the client. Although this system comes with flaws of its own we were able to make a hydroponic system that exceptionally meets all of the main client criteria. The system built can approximately yield 45 plants. Depending on the size of the plants, this number will vary. It is an enclosed structure with two doors to protect from pests. The doors open to allow in natural light. When shut, there is an LED lighting system throughout the wall for the plants. It was made very durable and structurally sound. The system comes with wheels making it very portable and it also fits in a standard sized elevator. The system also comes with branding on the insides of the doors that clearly displays the Growing Futures logo.

Design Flaws:

Design flaws on the hydroponic system include an inconsistent dripping system. The water flowing through the tubing did not drop through every hole. Moreover, the size of the system was too large and not easily accessible by children. A future improvement could be a smaller system. Another design flaw was the lack of siding on the pvc piping that held the plants.

This caused water to spill over the sides after time. A future improvement could be a piece of material placed at the ends to trap the water. Other improvements that could be made on our hydroponic system include larger tubing for water distribution and a powerful pump. Doing this will improve the consistency of the water distribution. Waterproof material is another improvement that could be made on the water system. Finally, automating the system and reducing the involvement of the client in the system's function is another improvement that could be made. The pressure of budget and time largely affected the construction of the wall. A more evenly distributed workload also would have improved the quality of the hydroponic system.