Final Report
Blackboard Hydroponics

GNG1103[C]

Abstract

Hydroponics are a modern method of growing plants that is simple to do as well as having a minimal toll on the environment. Growing futures is a social enterprise that seeks to teach kids about business with real experience by selling plants grown with these hydroponics systems.

The following paper follows the journey our group took as they designed and built a hydroponics system designed for the children. It also features the specifications of the design as well as futures endeavors.

Group C3

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Introduction

This report explains the numerous steps taken to create a vertical hydroponics designed specifically for children who are attempting to learn how to grow organic food as well as adapt financial literacy. The purpose of this paper is to illuminate the team's experience in resolving a problem by designing a solution while following a design methodology.

The design methodologies were learned during the engineering design course; GNG1103. In this course we were provided with hands-on and team-based introduction to product development and management principles. Although everyone has his/her own strategies of solving problems, the materials covered in this class significantly advances one's planning and procedures.

Customer Description:

During the first meeting with the client, when they gave the presentation to the class, the client expressed numerous issues with their current design of hydroponics. The main issues were:

1. There is no location for branding.
2. It is difficult to move.
3. The reservoir is too small.

It was important to empathize with the client, especially because the client is much more different than us. As university students, we have lived much longer than the children have, and as such will have different experiences. For children size will be a major issue, making sure our design is easily used by children is a primary concern. It was important to take the customers statements and transform them into need statements.

Customer Statements and Needs

Table 1- Customer Statements and Needs

#	Customer Statement	Translated Need	Importance (5=Highest)
1	The current model to too heavy for the students.	The model is easily lifted and moved by the students.	5
2	The current model cannot fit inside of the elevator.	The model is small enough to be transported easily.	4
3	The current model is difficult to move.	The model is light in weight and easily moved.	3
4	The current model's reservoir is too small.	The model has a larger reservoir.	3
5	There is no way of knowing the current fill level of the reservoir at a glance.	The model has a way to read the current level of water within the reservoir easily.	2
6	The water dropping system is inconsistent, making some of the water miss the plant.	The model has a consistent water dripping system.	4
7	The cost of the current model is too expensive.	The model is affordable in price.	4
8	The lights cannot extend and change angle to enough extent.	The model has lights that are easily maneuvered to obtain any desired arrangement.	1
9	There is no place to place a sponsor's logo, or any other branding.	The model has an easily viewed location where a logo or brand can be displayed.	3
10	Modules can be taken out to harvest.	The model is modular.	3
11	The reservoir of the current model is difficult to clean.	The reservoir is easily accessed and simple to clean.	4
12	The growing trays are too heavy for one student to lift.	The growing trays are easy to move even for children.	5

Benchmarking:

The group has chosen three essential design features to include in the model: Weight and mobility, cleanup and reuse, and reservoir size. Three designs were chosen based on the features to compare using benchmarking: Andrew's second design for mobility and cleanup-reuse, Yorsaliem's third design for branding and reservoir size, and Sujan's first design for portability. These three options are rated on a scale of 5, 5 being the best in each category.

Table of Benchmarking

Table 2- Benchmarking

Hydroponics System		SucSeed		ZipGrow Farm Wall	
Specification	Importance (5=Highest)	Value	Score	Value	Score
Cost	3	$350	3	$1200	1
Weight (total)	2	<75lb	2	~600lbs	1
Weight (grow tray)	4	N/A	3	~50lbs	2
Height	3	18.5"	3	65"	2
Reservoir Size	4	32L	2	70L	4
Number of Modules	3	12	1	64	3
Aesthetic	2	N/A	1	N/A	2
Child Usability	5	N/A	2	N/A	4
Total			17		19

Problem Statement:

Children need a hydroponics system designed for them that will teach them about entrepreneurship, containing a larger, easy to clean reservoir with an easily aligned dripping system, modularity, good lighting and spacing, and an area for branding, while also being lightweight and small.

Design Criteria:

Table of Design Criteria

Table 3- Design Criteria

#	Need	Design Criteria	Importance (5=Highest)
1	The model is easily moved by the students.	Weight (kg) Surface Area (m^2)	5
2	The model is small enough to be transported easily.	Weight (kg) Width & Height (m)	4
3	The model is light in weight and easily moved.	Weight (kg) Surface Area (m^2)	3
4	The model has a larger reservoir.	Reservoir Size (L)	3
5	The model has a way to read the current level of water within the reservoir easily.	N/A	2
6	The model has a consistent water dripping system.	Lost Water (L)	4
7	The model is affordable in price.	Cost ($)	4
8	The model has lights that are easily maneuvered to obtain any desired arrangement.	Range of Angles (^{0})	1
*9	The model has an easily viewed location where a logo or brand can be displayed.	N/A	3
10	The model is modular.	# of Modules	3
11	The reservoir is easily accessed and simple to clean.	N/A	4
12	The growing trays are easy to move even for children.	Weight (kg) Surface Area (m^2)	5

* Denotes a non-functional requirement

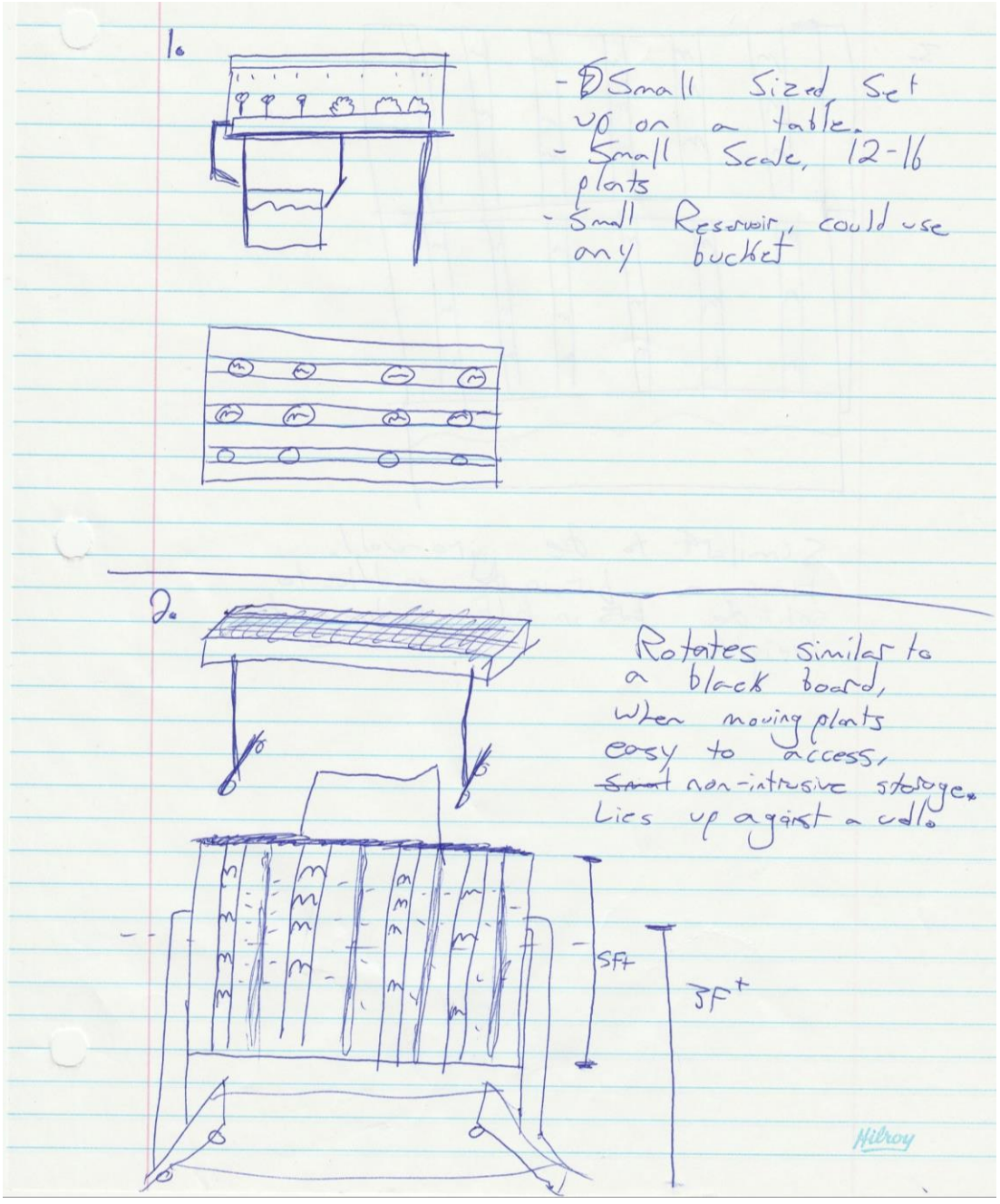
Table of Design Specifications

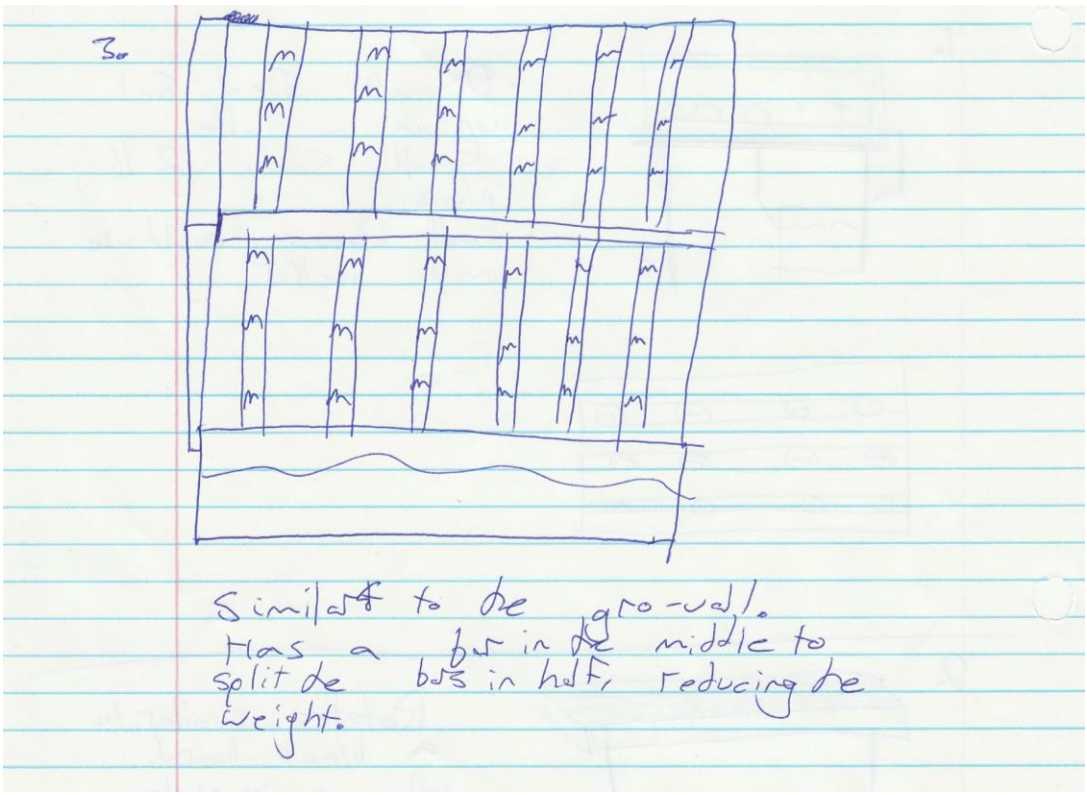
Table 4- Design Specifications

	Design Specifications	Relation	Value	Units	Verification Method
	Functional Requirements				
	Easy to Carry	=	yes	N/A	Carrying tests
	Easily Viewed Brand	=	yes	N/A	Number of Blind Spots
	Easily Moved	=	yes	N/A	Maneuverability
	Stable once in Place	=	yes	N/A	Attempt to Displace
	Constraints				
	Total Weight Without Plants and Water	<	300	lbs.	Scale
	Price of Model	<	750	$	Cost of Materials
	Height	<	2	m	Measure
	Water Loss	<	2%	L	Collect excess water
	Lightweight Growing Trays	<	25	lbs.	Scale
	Reservoir Size	>	70	L	Fill with Water
	Number of Modules	>	20	# of Modules	Count
	Non-Functional Requirements				
	Aesthetics	=	yes	N/A	Test in model
	Product Life	>	6	years	Test Durability
	Safety	=	yes	N/A	Test
	Child Usability	=	yes	N/A	Test

Generated Solutions:

Andrew:



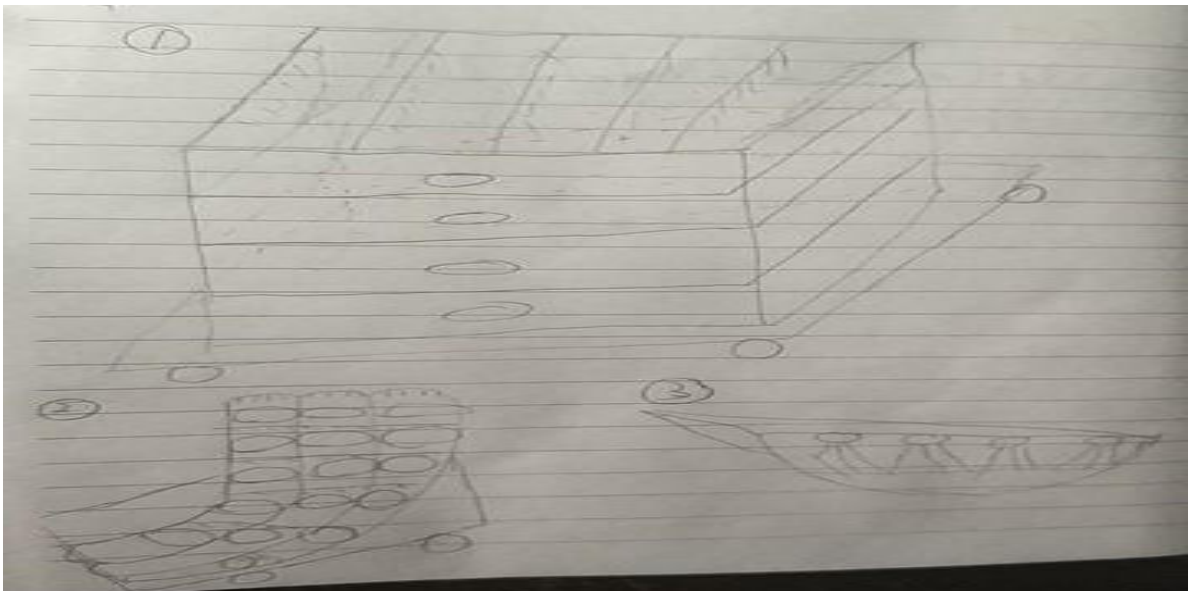


3 different concepts, based on the idea of small, medium and large.
The first model is designed to be placed on a school sized desk in a classroom. There would be a smaller yield, but many of these models could be placed in a classroom. This model is also very portable but would have a very small reservoir.

The second model is conceptually based on a rotating blackboard. By having the modules rotate from vertical to horizontal, the students will easily be able to make changes to the hydroponics system. The model is very mobile and can easily be branded.

The third model is a massive grow wall; however, it is not very mobile. It features a massive reservoir as well as many plants. This model is not mobile at all, once in place it will not be moved without great effort.

Qi:

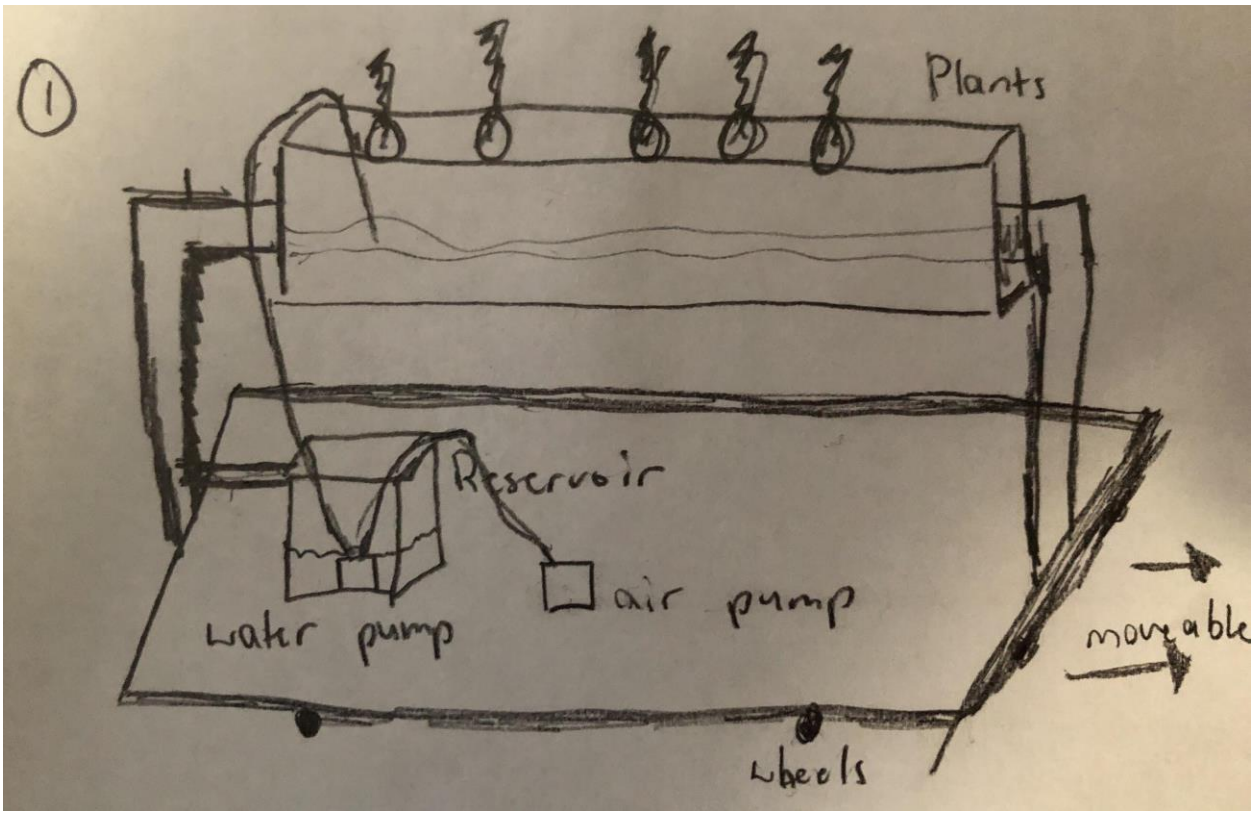


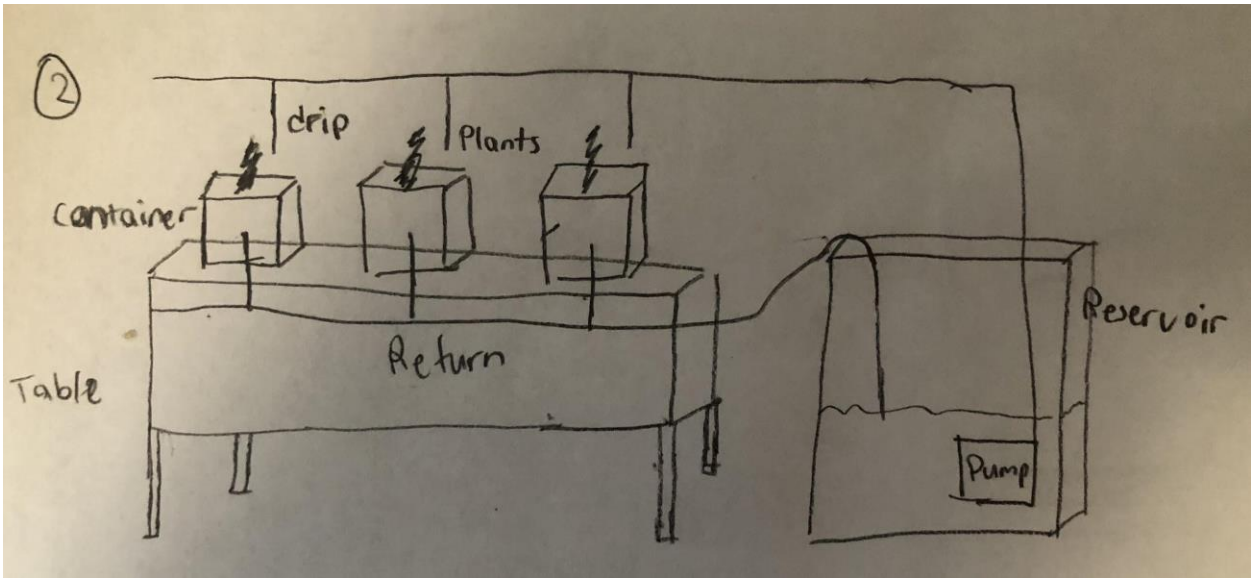
The first design is a removable cube with levels (looks like drawers). In the cube there are listed as columns and rows of plants. It is very convenient for kids to take out any levels and clean them. There are pipes around the side, so the nutrient can flow out and get exchange with an outside pressure pump. There are wheels designed fixed under the reservoir to convenient child moving it.

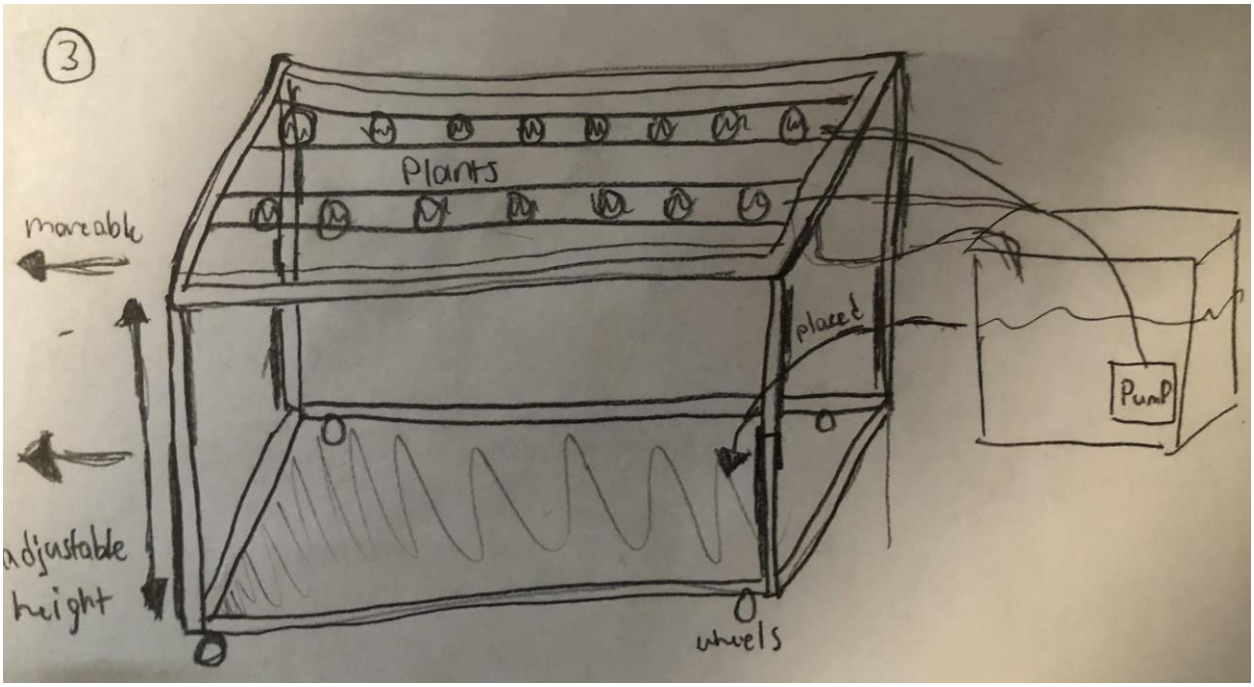
The second design is a side by side arc-shape reservoir which designed as nutrient pipe at side flowing and exchanging. There are pipes around the side, so the nutrient can flow out and get exchange with an outside pressure pump. Also, there are directional switch can make the plant taking out from bottom. The reservoir base is fixed on a plate with wheels.

The third design sketch is a half-sphere shape reservoir which design as plants at the top and their roots goes to the bottom for nutrient. Levels might apply to the reservoir if needed by listing the plants as arc and nutrient each level. This shape can be design with an electrical movement method or ropes at fixed side.

Sujan:


1
Plants
Reservoir
air pump
water pump
movable
Wheels


2
drip
Plants
container
Reservoir
Return
Table
Pump

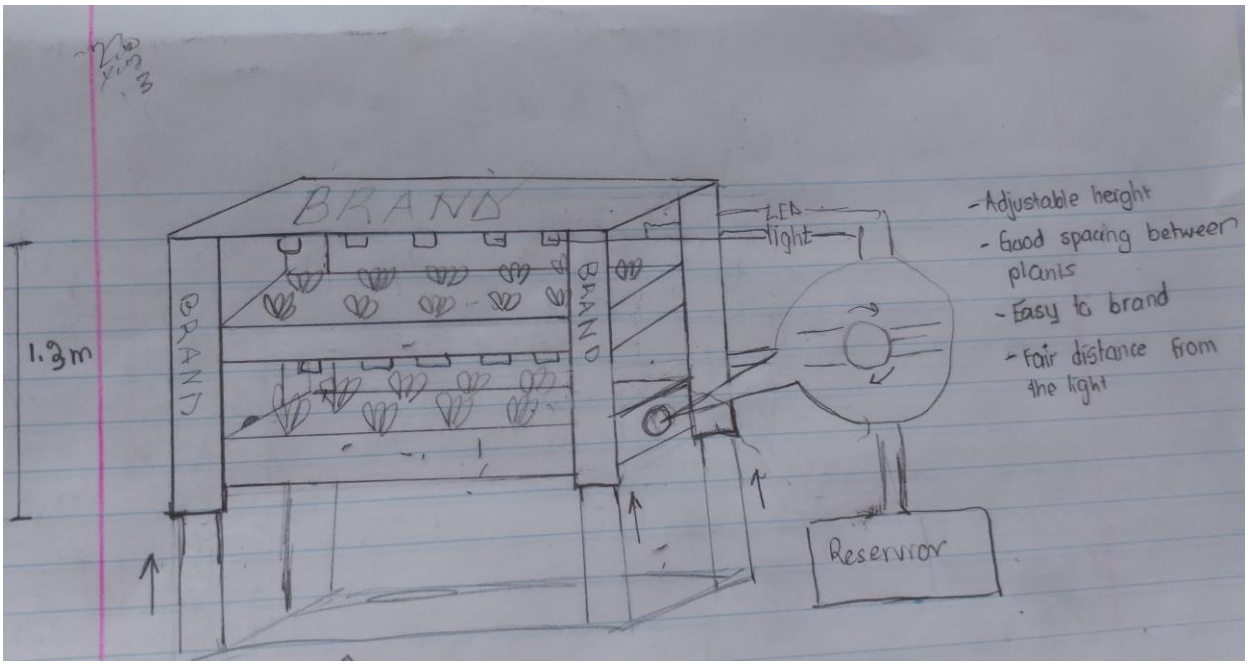


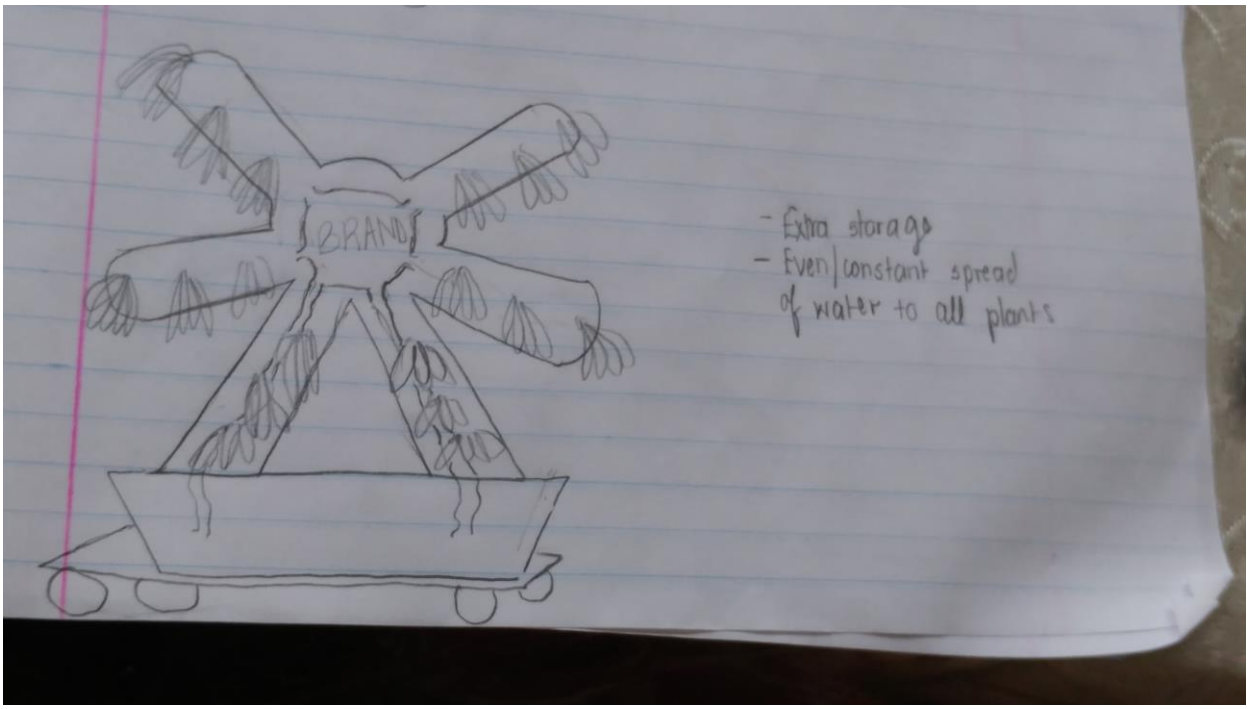
The first design is moveable like a cart due to its wheels, making it somewhat mobile and easy for children to move. It has drip and return lines. It has a lot of free space which can be used for branding. It can have for a medium reservoir size. The overall size is moderate, and the weight is a bit over moderate.

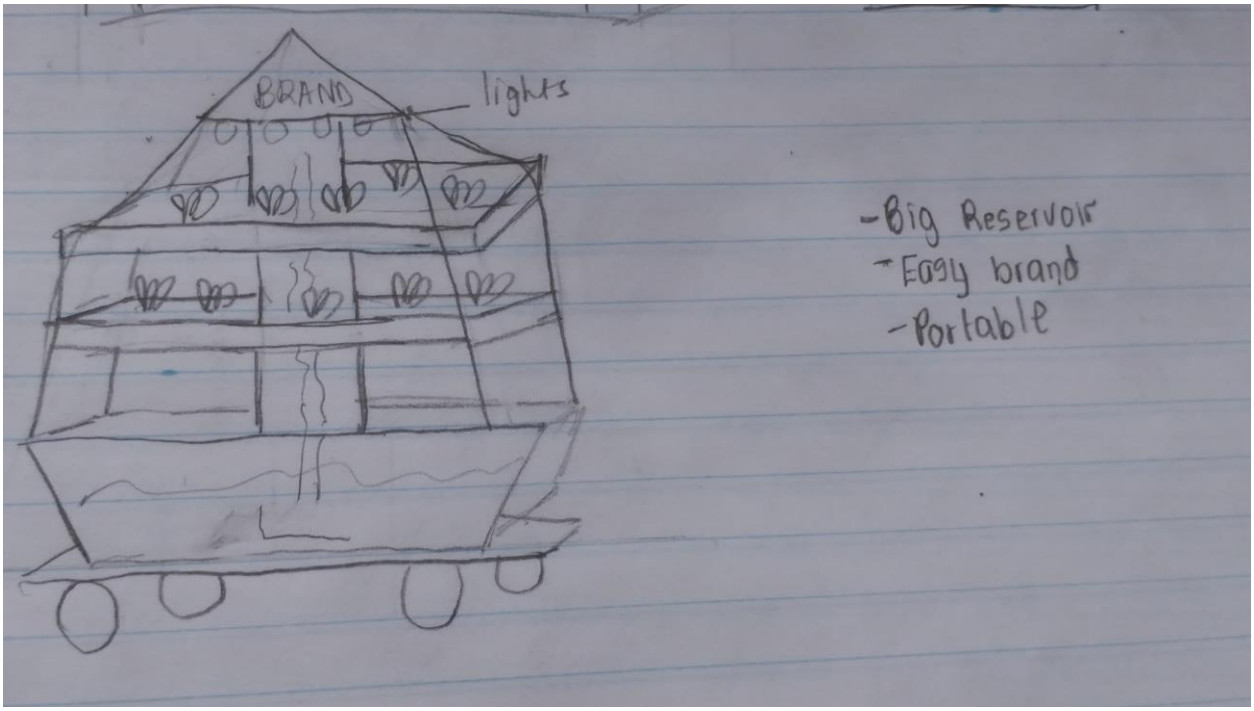
The second design is not moveable. The setup uses a table to place the plants on top of in separate containers. It has drip and return lines. The spacing between the plants is very good. There is also a lot of space for branding. It can have a large reservoir size. The overall size is large, and the weight is also large.

The third design is moveable like a cart due to its wheels, making it somewhat mobile and easy for children to move. It has an adjustable height which allows for it to be easily used by children. It has drip and return lines. It also has some space on the bottom for branding. It can have a medium reservoir size. The overall size is moderate, and the weight is slightly under moderate.

Yorsaliem:


BRAND
LED light
1.3m
BRAND
BRAND
Reservior
- Adjustable height
- Good spacing between plants
- Easy to brand
- Fair distance from the light


BRAND
- Extra storage
- Even/constant spread of water to all plants



The above three designs mainly focus on different functional requirements while trying to check all/most of other requirements and constraints.

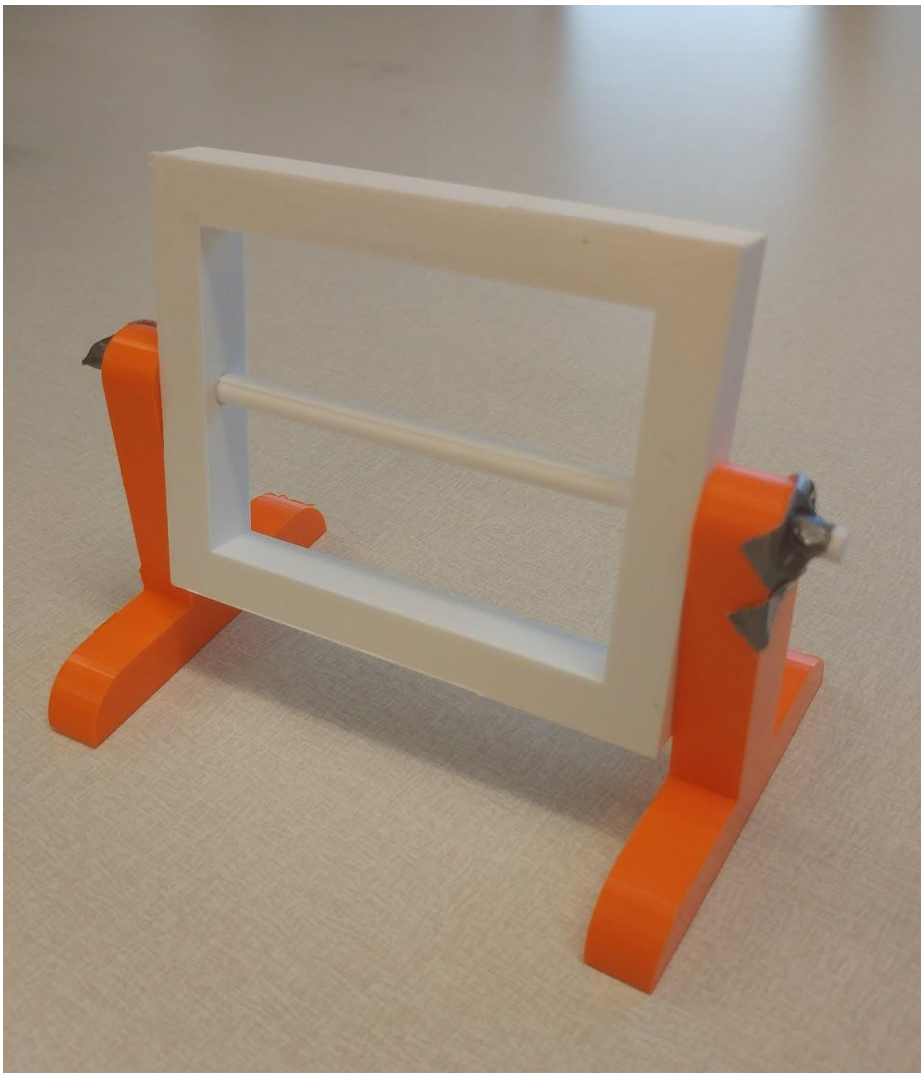
The first design mostly focuses on adjusting the height of the hydroponics system for the users (children). Inspired by an adjustable office chair, the users can increase or decrease the height of the system by rotating the handles on either side of the bottom tray. Furthermore, the systems tend to have reasonable spacing from the lights to plants as well as between the plants. With this design, it is also possible to grow more plants.

The second design aims to have a larger reservoir. Since the reservoir is at the bottom, it makes it easier for the users to fill it with water. In the reservoir, it has a programmable device to pump the water up. Made from a PVC pipe, its ‘stem’ attaches to both the large reservoir and the plants branched out. Additionally, the system has wheels at the bottom making easy to move.

The last design aims at having extra reservoirs and being portable. At the bottom of the hydroponics rests a large reservoir with a water pump and wheels. The wheels make it possible for the system to be portable while the pump provides force to transport water to the top. At the middle, there is a smaller reservoir shaped somewhat circular. In the second reservoir rests another pump that evenly distributes water to the plants across each branch.

Testing Objectives and Results:

First Prototype

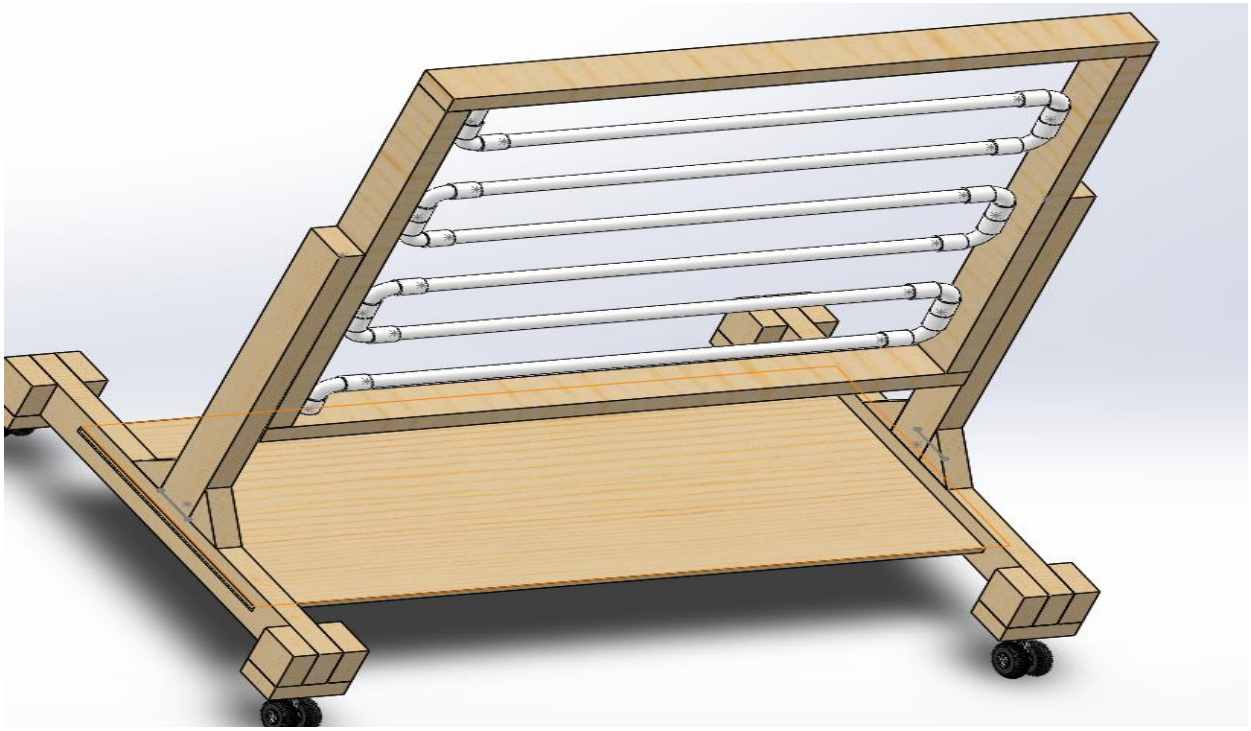


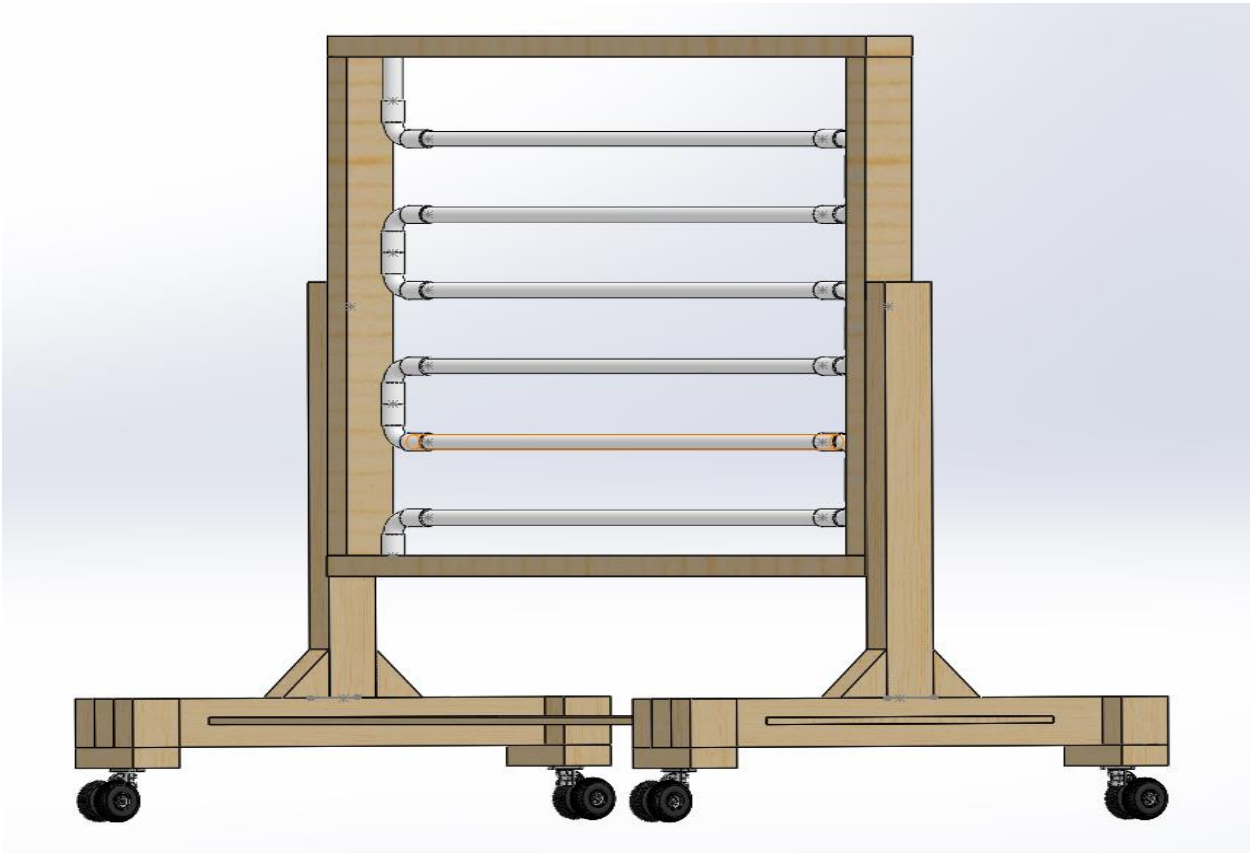
Vertical position.

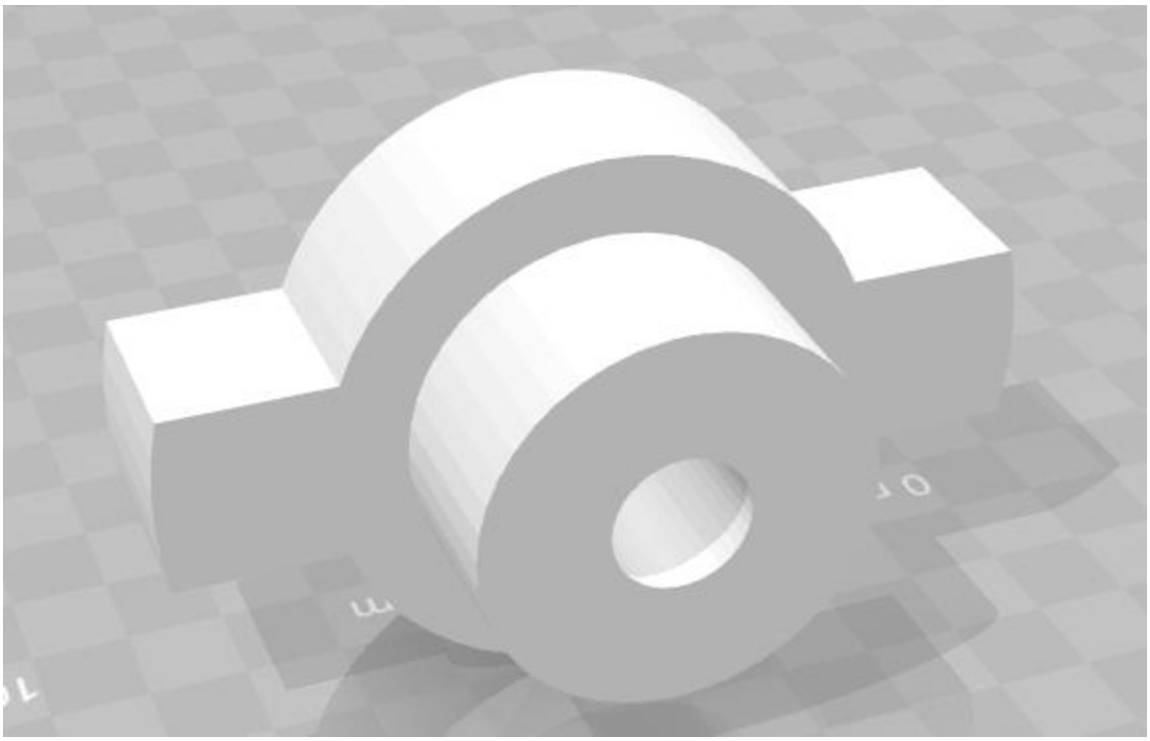
Horizontal position.

The purpose of the first prototype was to demonstrate our idea to the client as a more tangible version of itself. It is easier for the clients to understand our design if it is as a model than as a drawing or a description.

Second Prototype







For the second prototype, the entire model was built using solidworks 3D modeling. The main subsystem that was being tested was the rotational stop that would prevent the design from traveling too far when rotating from horizontal to a vertical position and vice-versa. The design functioned to specification, however it was deemed to complex and would not be needed for the final prototype.

Third Prototype


niques
wall
HDX

The third prototype was the culmination of our efforts this semester and can be seen above. The modifications from the second prototype include a different arrangement of the pipes, a latch to keep the frame in place, and a different piece of wood acting as the rotational stop.

Technical Specifications of the Third Prototype:

Measurement	Unit	Value
Height (Vertical)	in	60
Height (Horizontal)	in	40
Width	in	32
Length	in	45
Plant Locations	#	30

Conclusion and Recommendations:

Next Step:

The next step for this project is to attach lighting to the system, as well as a reservoir and pump. It has already been prepared to accommodate these additions. For lighting, led strips will be used on the underside of each pipe, illuminating the plants directly beneath. For a pump and reservoir, a reservoir will be made of 2 Rubbermaid totes connected via a pipe. The pump will carry water to the top with plastic hose and will be brought back down due to gravity.

Lessons learned and future:

Early on there was an issue in group communication and work completion. This led to a group member feeling dissatisfied with the group and he ultimately ended up leaving. After this, the group began to take things more seriously moving forward. The size of the project was also ambitious

Final Comments:

Working with the children as the main client was an interesting experience. As they were young they had difficulties expressing their thoughts and needs for the project. It was a good experience and we would do it again.