GNG1103

Design Project User Manual

[User Manual]

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Date: 10-04-2020

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Abstract

This report provides information about the design process for the construction of a greenhouse structure designed with the plan of providing the needs that exist for members of the Algonquins of Barriere Lake community. Also, this report describes how the prototype is made, used, and maintained. Furthermore, it includes the lesson learned and recommendations on improvement needed to construct a more suitable design for future work.

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Glossary

Glossary	Definition
Copper Mesh	A brown ductile, flexible, high thermal and electrical conductivity material with tiny holes used to keep rodents away.
Empathise	It involves consulting experts about an area of concern through observing, engaging and empathizing by asking open ended questions (interview) with clients to gain empathic understanding of their experiences and motivations.
Define	Involves putting together the information created and coming up with the problem statement.
Ideate	It involves creating a solution to the problem already identified, getting feedback from the client and adjusting the problem statement if need be.
Prototype	Inexpensive versions of a product for the purpose of re-investigating and improvement on the basis of the client's feedback.
Test	Alterations and refinements that are made in order to rule out problem solutions and derive as deep as understanding of the products, its users and conceive a solution.
PVC	Stands for polyvinyl chloride. A very durable, easy to install and lost cost plastic pipe used for piping.
Vinyl sheet	A transparent, waterproof material, made from PVC which prevents moisture, dirt and dust from entering an enclosed space.

1 Introduction

Access to fresh produce is something that we often take for granted in developed cities; however, in remote areas, fresh produce can be hard to come by. Our client, Monique Manatch, is a representative of a remote Algonquin community in Northern Quebec. Throughout the Winter semester, we worked with Monique to create a greenhouse that suited her desired needs. She requested that we build a greenhouse system that would shelter fresh produce for the community all year round.

Our mission was to produce and increase accessibility to adequate amounts of natural food produced for members of the Algonquin of Barriere Lake community all year round. This design needed to be affordable, sustainable, easy to use, remain functional during the cold winter months, and be resistant to rodents. Thankfully, we were given the opportunity to create an inexpensive greenhouse to meet her needs; our solution had to meet specific needs of the client and we utilized a budget of $500 to achieve these goals. Thus, our team created a design that was going to solve the inconsistent food delivery.

This report will provide an overview of the design thinking process. Firstly, the empathise step of the design thinking process was utilized through meetings with our client, Monique Manatch, where she expressed the community's trouble with the inefficient system that exists. From that information, the team was able to define the problem and list the needs. During the ideate stage of the design thinking process, we sketched three concepts, and we gathered feedback from our TA, client, and Professor. After a general design was chosen, among 3 different concepts, physical prototypes of different levels of detail were built to improve spatial understanding of the design. Then, the last stage is where we test our Design.

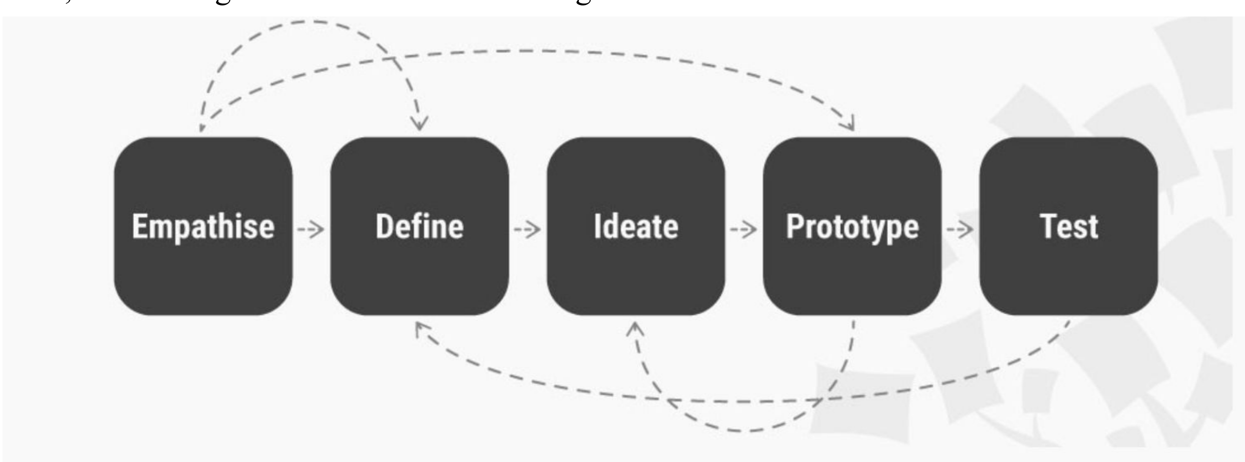


Figure 1: THE FIVE ENGINEERING DESIGN PROCESS

1.1. The Problem Statement

On the 22nd of January 2020, we met with the client, Monique Manatch, to discuss the construction of a greenhouse for the Algonquins of Barriere Lake community. The community is facing an inadequate food supply alongside a lack of proper water supply and electricity. With the information that we gathered from our client, we developed the following problem statement: "The need exists for members of the Algonquin of Barriere Lake community to increase their food supply with the use of an efficient, sustainable greenhouse hydroponic system that is easy to control, compact in size, insulated, affordable, and able to provide warmth all year for growing plants". After meeting with our client, we discovered how our customer wants the product to perform. However, Customer Needs are non-technical, and they reflect the customers' perception of the product, not the actual design specifications.

Our two primary goals are:

1. To keep the product focused on customer needs.

2. To identify not just the specific needs of the customer, but also the latent needs.

These customer requirements:

1. Gather raw data from customers

2. Interpret the data in terms of customer needs

3. Organize the needs

4. Establish relative importance of needs

5. Reflect on the Process

Without the customers' input, it would be impossible to identify their needs. The goal is to elicit an honest expression of needs, not to convince the customers of what they need but to use the data we collect to serve as guidelines for product development.

1.1.1 <u>Fundamental Needs</u>

Customer Needs Identification defines the problem that we engineers need to solve. The most significant defect a product can have is not satisfying the customer. We are going to build a system that would meet the specifications of the customer, and any extra features that do not contribute to the customer's appreciation of the product would be avoided. Time spent working on those features is the time taken away from the critically important ones, and even assuming that we meet all of the requirements, adding the extra features takes time and money that could be put to other uses. However, it is our duty to anticipate essential needs that the customer might not have recognized, but not frivolous features.

Table 1: A list of Interpreted Needs from the customer.

NUMBER	CUSTOMER STATEMENT	INTERPRETED NEEDS	IMPORTANCE (numerical ranking)
1	There is no electricity available to power the community as they survive on generators.	The greenhouse should be highly sustainable. For example, wind and solar energy would be used.	4
2	There is no availability for the nutrients needed to feed the plants.	The greenhouse hydroponic system should be able to supply nutrients to itself. i.e. self-sufficient.	3
3	Average temperature ranges from -33°C to 4.1°C	The greenhouse hydroponic system should have its own heating system.	4
4	There is a shortage of water supply available in the community.	The greenhouse should have its own water filtration system.	4
5	Dimensions should be between 4x8 inches or 6x6 inches.	The greenhouse should be compact in size.	4

6	The community is far from the building site (university), so it needs to be disassembled when it's transported.	The greenhouse should be easy to assemble and disassemble easily when transported.	3
7	The community is entitled to very basic equipment.	The greenhouse hydroponic system should be easy to maintain.	2
8	Animals in the area can damage the plants.	The greenhouse should have a barrier.	5

1.1.1.1 <u>Differentiation between our product from others</u>

What distinguishes us from other teams is that our design is large enough to cater large amounts of food supply for the community. With our design, we aimed to satisfy all of the customer requirements and to consider extra features to improve the user experience. We discovered that last year, the clients did not like the idea of decorative lights around one of the group members' designs, so we put that into consideration and delivered a simple but functional design. The following report will describe how we used the design process and relevant information from all groups deliverable to create our design.

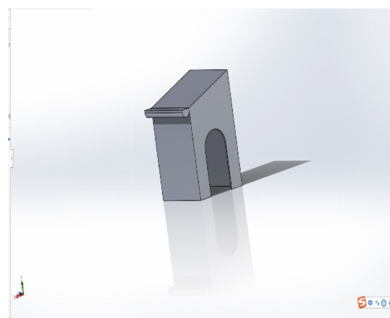
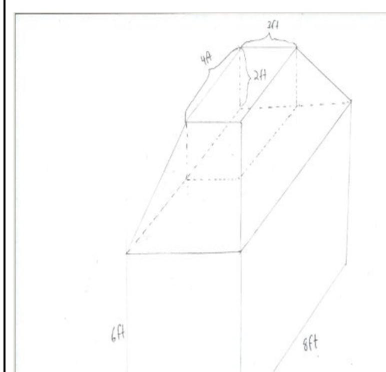
1.1.1.1.1 <u>The Main function of the Product</u>

The most significant defect a product can have is not satisfying the customer. We are going to build a system that would meet the specifications of the customer, and any extra features that do not contribute to the customer's appreciation of the product would be avoided. Time spent working on those features is the time taken away from the critically important ones, and even assuming that we meet all of the requirements, adding the extra features takes time and money that could be put to other uses. However, it is our duty to anticipate essential needs that the customer might not have recognized, but not frivolous features.

2 How the Prototype is Made

Before the prototype was constructed, we benchmarked our three designs to decide which is easy to control, compact in size, and affordable. In this phase, in groups of two, our team came up with three concepts and sketched them out. The first and second concept was created using solid works, and the last was drawn with a pencil.

Table 2: Benchmarking: short description and an evaluation for each specification on a scale of 1-3: 3-Green, 2-Yellow, 1-Red (3 BEING THE HIGHEST).

Specification	Concept 1	Concept 2	Concept 3
Sketch			
Description:	This design is a gambrel roof design that has a regular two-sided structure with 2 slopes on each side. It was chosen because there were available wood scraps from previously used wood. So instead of using fresh wood, we maximized cost by using the wood scraps to construct this concept.	This design is referred to as a skillion design, due to its single, sloping roof. It was one of our solution options because we were informed by our client that there is usually heavy snow and rainfall in the area, so we thought about this roof because snow and rainfall would be able to fall off easily. Also, it is also easy to assemble and disassemble because of its simple structure.	This style of roof allows for a great collection of water, and also diversifies our options when it comes to the placement of a solar panel. This design was not chosen because of the excessive weight which the tank provided on the building itself.
Product life Span	Five years	Five years	Five years
Rodent/insects Resistance	yes	yes	yes
Dimension	(9 x 6) ft	(8 x 6) ft	(6 x 8 x 6) ft
Easy to assemble and disassemble	yes	yes	no

Weather resistant	yes	yes	yes
Price	Cheap	affordable	expensive
Water Collection	great	great	excellent
Snow load Resistance and Capacity	yes	yes	yes
Ventilation Included	yes	yes	no
Space available	yes	Instructions would be given, but can be tricky	Instructions are given, but would definitely be tricky
Frame material	Wood planks, plexiglass or plywood	Wood planks	Wood planks and polyethylene film
Time and energy consuming	no	Takes more time to build than concept 1 but takes less time to complete than concept 3	yes
Tools needed for maintenance	Screw and nails	Nails, Bolts, Nuts	Screw, Bolts, Nuts
Doors Included	yes	yes	yes
Weight	119lbs	114lbs	260lbs
Total Score	40	35	25

Before constructing the greenhouse, as a team, we brainstormed the most important features and solutions for our client to be satisfied. These features include the following: roof structure, water collection, heating system, portability, and pest control, which will further be explained in the report (instruction part).

2.1 Category

2.1.1 BOM (Bill of Materials)

The bill of materials (BOM) is required to keep track of all the materials used to build the greenhouse. There were some concerns while making the BOM that the greatest of the materials used to construct the greenhouse were given to us during the Construction lab. In this case, the value of the greenhouse, shown in Table 3, may cost a bit more than the actual cost.

Table 3: List all the parts and materials.

Item # 1	Material	Element of Structure	Quantity	Dimensions (ft.)	Unit Cost/$	Total Cost/$
1	Wood	Base	6	2x4x8	3.25	19.5
2	Plywood	Flooring	2	(11/32 inches) x4x8	15.53	31.96
3	Wood	Front and Back Frame (Walls)	12	2x4x8	3.25	39
4	Wood	Side Frame (Walls)	14	2x4x8	3.25	45.5
6	PVC (plastic)	Roof Panels	5	2x8	25	115
7	Wood	Roof Frame	6	2x4x8	3.25	19.5
8	Vinyl Sheet	Wall coverings	8 rolls	4.5x45 (16 mil thickness)	3	24
9	Plastic	Gutters	1	8 ft long	3	3
10	metal	Nails, screws and rafter hangers	N/A	N/A	30	30
11	Paints	Base Structure and Bottom wall	2	N/A	3	3
12	Wood	Support	N/A	N/A	LEFT OVERS	
13	Plywood	Door (exterior) and bottom wall	1	(11/32 inches) x4x8	15.53	15.53
14	Copper Mesh	Base	1	45 X 12 inches	37.93	
				Total Cost Estimate	$ 383.92 + tax	

2.1.2 Equipment list

During the construction of our greenhouse, there were a few different equipment and tools used to assemble the parts.

Table 4: List of Equipment and tools.

#	Tools and Equipment	Used for what?
1	Drill	connect the parts of wood
2	Hammer	connect the parts of wood
3	Nail Gun	connect the parts of wood
4	Tape measure	measure the pieces of wood, roof paneling, and vinyl sheet
5	Table saw	cut the pieces of wood

2.1.3 Instructions

Base:

The first component of the greenhouse that should be constructed is the Foundation (base). The strength of a greenhouse lies in its foundation because it holds the structure above and keeps it upright. The material used is Lumber wood for the frame of the base and plywood for the flooring of the base, and the dimension is 8x6 feet. In figure 2, we used SOLIDWORKS to help stimulate the physical behavior of our design.

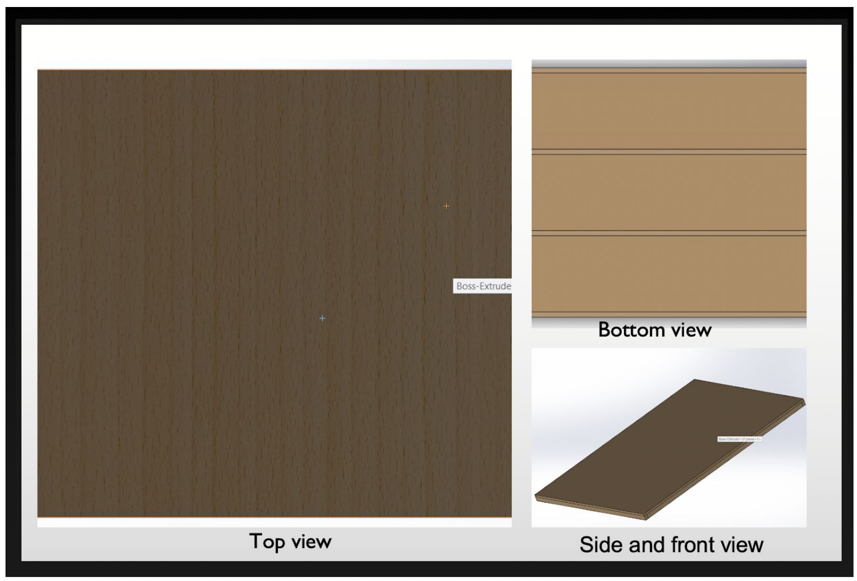


Figure 2: Base of the Greenhouse.

Walls (frame)

Once the base is complete, the next part that should be worked on is the walls of the greenhouse. The walls of the greenhouse are made by 2X4 lumber and are held together by nails. intotal 4 walls are required, 2 walls that are 8 feet in length and 6 feet high, and another 2 that are 6 feet long and 6 feet high. Drawing a sketch of the walls can help to determine what dimensions are required to make each set of walls.

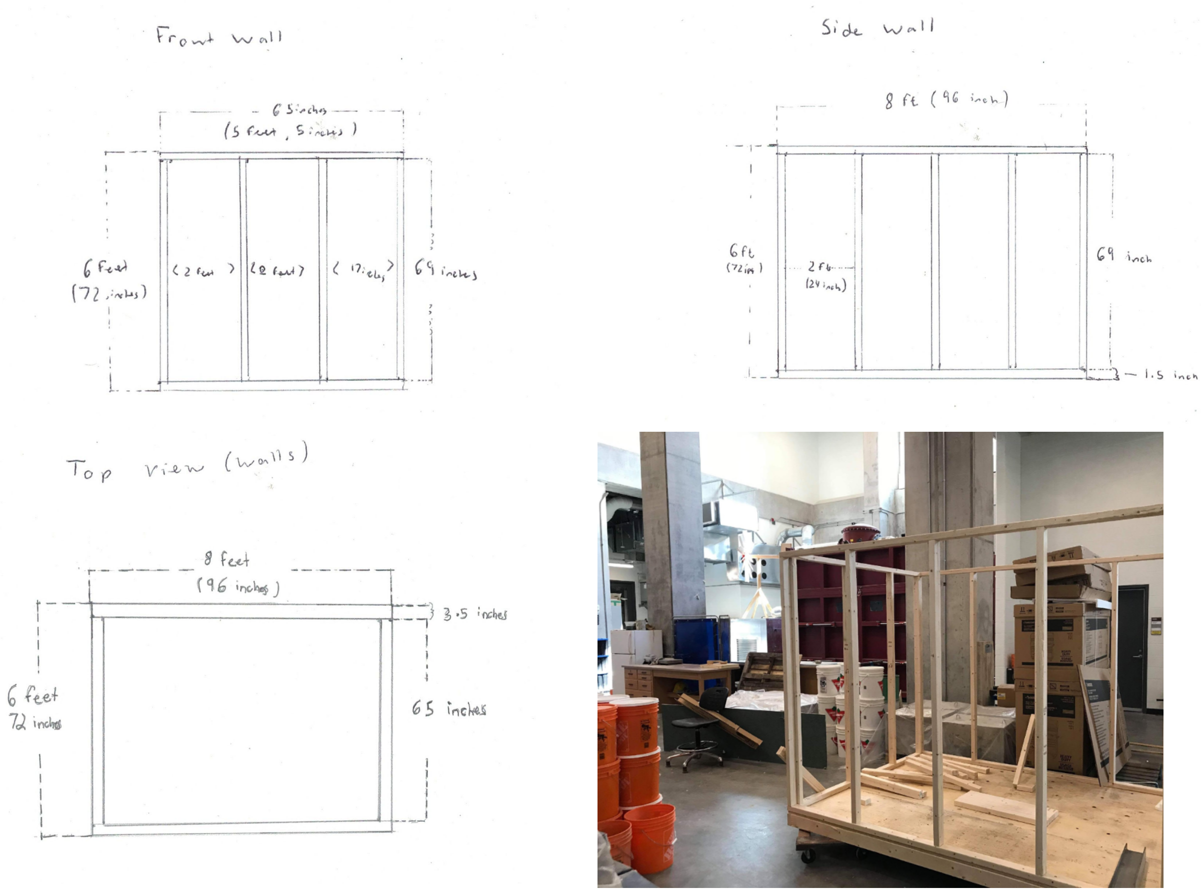


Figure 3: Walls of the Greenhouse

With the sketch, you can determine how many pieces of lumber are required and the dimensions of each piece. Once all the pieces of wood are cut to size, the assembly of the walls can begin. The lumber was joined together using nails; however, screws were used to assemble the walls onto the base of the greenhouse. The screws allow for easy disassembly for transport.

Roof :

As the walls were completed, the roof frame of the greenhouse was next. A gambrel roof style was chosen. A gambrel roof design has a symmetrical 2-sided structure with 2 gradients on each side. The lower sloop is very steep, usually around 60 degrees, while the upper slope has a much shallower angle, at approximintly 30 degrees. The steep slopes of the roof allow for good drainage while also maximising the space in the greenhouse. The roof frame is made out of 2X4 lumber which is joined together by plywood and nails. 5 pieces where required to fit the greenhouse. Moreover, we connected all the roof frames using screws and rafter hangers on each side for the greenhouse to be easy to assemble and disassemble when it is being transported. Finally, once the roof was assembled and joined to the walls of the greenhouse, PVC roof panels were nailed to the frame of the roof. The PVC roof panels are clear so they allow maximum sunlight into the greenhouse while still being strong enough to hold rain and snow.

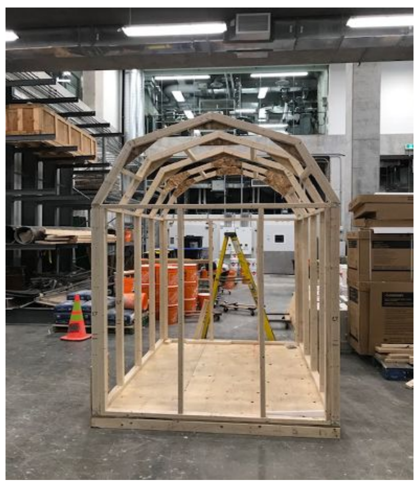


Figure 4: Roof of the Greenhouse

Plywood (on the bottom and top of the walls)

Plywood was used all around the base for more stability and protection from the rodents. Also, wood planks will line all 4 sides of the walls. The planks will be 2 feet in height. This will increase the strength of the structure of the greenhouse, which will provide protection against strong winds.

Figure 5: Wind and Rodents Protection

Other Future Work:

Due to the pandemic outbreak of COVID-19, our building construction was still not yet completed. While noting social distancing limits for safety reasons, the remaining components of the greenhouse will be described to our client in order to have a clear idea of what would have been completed if COVID-19 did not exist.

The door will open outward to prevent space loss in the greenhouse. It will be the height of 6 ft. and it will have a width of 2 ft. The door will be made out of wood (exterior) and Vinyl (interior) to provide more sunlight to enter through.

For wall coverings, vinyl sheets will be used to provide airtight insulation allowing the heat to stay within the greenhouse while also allowing in ample sunlight. The Vinyl sheet will also provide protection against harmful UV rays. Also, we were going to install copper mesh on top of the plywood to prevent any rodents from entering the greenhouse. Copper mesh has tiny holes, and it is easy to install, so it was a suitable choice for protecting the greenhouse.

There will be a gutter, made of plastic, at one side of the roof of the greenhouse to collect the water from the roof to the rain barrel.

3 How to Use the Prototype

The main function of the greenhouse is to trap heat from the sun to keep the inside of the greenhouse warmer than outside. This allows plants to be grown all year round. In order to allow heat from the sun to enter the greenhouse but not exit, a clear plastic film was used as the walls of the greenhouse. The transparent walls allowed the heat to enter, while also acting as an insulator and keeping the heat inside.

The greenhouse also acts as a shield for the plants to protect them from harsh winds, violent rain, insects, and animals. A plywood barrier of 1 foot and 4 inches in height was used to line the bottoms of the walls to keep insects and rodents away from plants. The barrier also acted as extra support to make it more stable in order to protect it from harsh winds.

To operate the prototype safely and effectively it is important to ensure that the clear coating around the greenhouse is always in good condition and not punctured or ripped. Any holes in the film can allow insects to enter the greenhouse and most importantly allow heat to escape. It is also important to ensure the door is always properly closed as the door is a large area that can allow a majority of the stored heat to escape.

Furthermore, the greenhouse is a self-watering system that uses rainwater to keep the plants hydrated. However, if there is no rain for a long period, the plants can get dehydrated and potentially die. Therefore, it is important to monitor the amount of water in the reservoir tank and determine if the plants need to be manually watered until more rainfalls.

4 How to Maintain the Prototype

The test to observe the ability of our greenhouse to supply the needs of the client while maintaining our client's specifications was paramount. If our materials are strong enough, despite different weather conditions or seasons, it would significantly conserve the plants inside.

As a result, for the testing of the final prototype, we poured a bucket of water on the roof to test whether or not the water will fall smoothly to the ground. In addition, we have also tested the stability of the product by jumping on the floor and shanking the walls of the greenhouse. Based on the testing, it has passed all the targeted specifications needed by the client.

Regular maintenance that should be performed on the prototype to avoid failure is to check if any water has leaked into the greenhouse and if the temperature stays constant. The vinyl wrap may be prone to break and may need to be replaced, since animals or sharp objects may puncture it. In this case, check the clear vinyl wrap to see if there are any punctures. Moreover, gutters should be checked from time to time to see if it is clean from all the polluted particles that may have fallen into it and assure that the pathway is not blocking the flow of water. Most importantly, check for any damages done to the copper mesh as animals may have tried to get in.

5 Conclusions and Recommendations for Future Work

Team-work was a valuable lesson learned throughout the project and would undoubtedly be essential in future projects.We learned to;

- Manage strict budgets provided to us by the client.
- Plan ahead and manage time effectively.
- Break and tackle complex tasks simpler/into parts and steps.
- Give and receive feedback from one another, client, TA's and professor.
- Diversity amongst the group helped us to challenge ourselves.
- Establish new approaches to resolving differences.
- Delegate roles and responsibilities.
- Develop our own individual voices and perspectives in relation to our group members.
- Use the right materials for every specific task to ensure consistency.

From this project, we learned the importance of using appropriate materials for the right task at hand. In the beginning, our team wanted to use a gable style design for the roof because it required minimal effort to assemble and disassemble, but given the limited time and resources assigned, it was not the most suitable choice. However, after speaking to the professor, he advised us to use the remaining cut out scraps(wood) that were left to design a firm roof. Even though the gable style was the easiest choice for the job, it was much more expensive to assemble compared to the gambrel style. In the end, we decided to go with the gambrel roof for the roof design and learned a valuable lesson about using materials that are appropriate for the given project. Also, the use of a Gantt chart was extremely helpful when delegating tasks, as we learned how to manage time efficiently by remaining focused throughout the semester to ensure the project was completed on time.

Due to the pandemic outbreak of COVID-19, our building construction was brought to a complete halt.

The following are the remaining work that was needed to be completed:

- We were just about to add the hydroponics design to the greenhouse
- Wrap the whole-body frame with the transparent material (vinyl sheet) using staples
- Add the mesh to the base of the building frame
- Add a bottom base protection to the bottom to lift the whole building up
- Add the door to the whole frame and paint it
- Finish Deliverable I (status Update)
- Update Trello week 10
- Perform more strength tests analysis and add finishing touches to the greenhouse

Overall, the construction of the greenhouse project was successful, and it reflected the skills and methods explained from all lectures by using the five engineering design process. This course, as well as the build of this project, clearly presents students with interest when encountering future design obstacles. We reflected on the client's needs in our design, and by doing this, we made her satisfied. Moreover, we are happy and confident with our design and hope to be given more opportunities to put our knowledge and skills to the test, as this was a very nice experience for us.

Bibliography

1. “Top Sheeting Rolls - 1.5 Mil, 60 x 60.’” *Uline*, www.uline.ca/Product/Detail/S-6020/Top-Sheeting/Top-Sheeting-Rolls-15-Mil-60-x-60?pricode=YF790&gadtype=pla&id=S-6020&gclid=CjwKCAjwssD0BRBIEiwA-JP5rKyH6qLt4nxH57tpyk4byz7wJKeYmABY_YssYUQCeONYjtjLHNYQShoC-5MQAvD_BwE&gclsrc=aw.ds.
2. “What's the Difference Between PVC and CPVC Pipe.” *CIS Blog | Industrial Supply Tips, Specs & Product Information*, 15 Aug. 2017, www.commercial-industrial-supply.com/resource-center/whats-the-difference-between-pvc-and-cpvc-pipe/.
3. “Exclusion With Copper Mesh.” *Solutions Pest & Lawn*, www.solutionsstores.com/exclusion-with-copper-mesh.
4. Dam, Rikke Friis, and Yu Siang Teo. “5 Stages in the Design Thinking Process.” *The Interaction Design Foundation*, www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process.
5. “Sign In.” *Greenhouse Construction D2 | MakerRepo*, makerepo.com/mabde074/greenhouse-construction-d2.

APPENDIX I: Design Files

All design files can be found in MakerRepo by using the following link below:

https://makerepo.com/mabde074/greenhouse-construction-d2

This link will provide a relevant summary from all group deliverables of our greenhouse during the semester.

APPENDIX II: Other Appendices

Figure 6: Vinyl sheet

Figure 7: Copper mesh

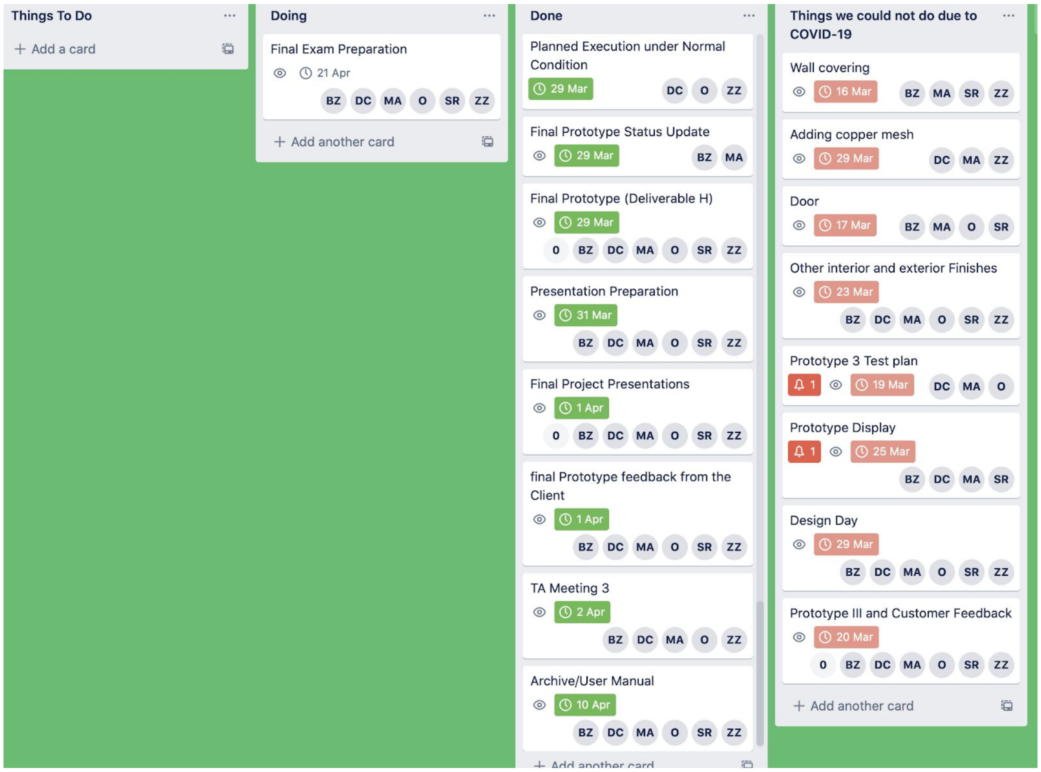


Figure 8: Last Trello Table

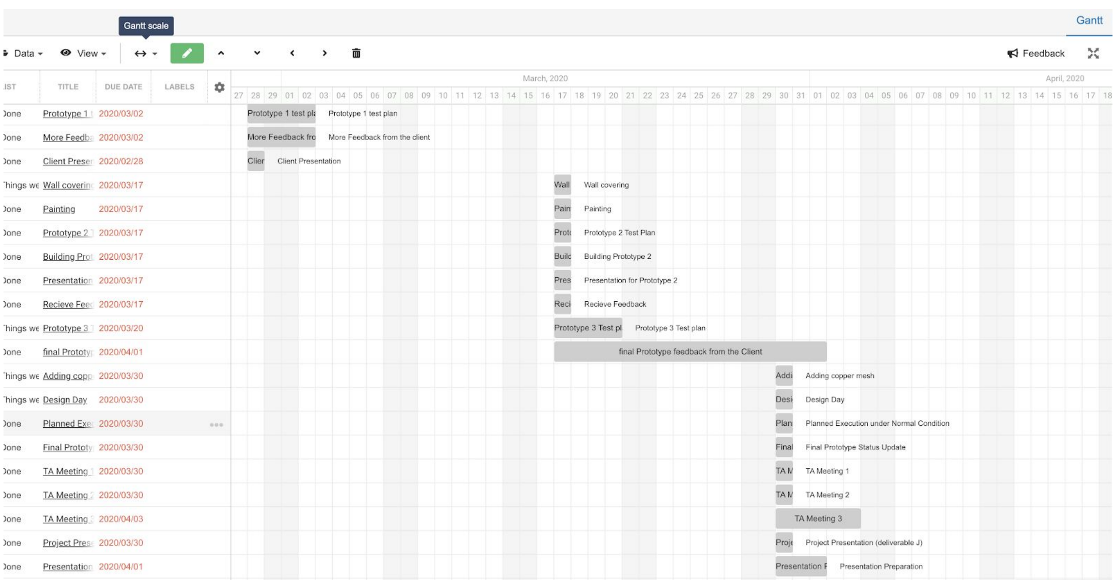


Figure 9: Last Trello Gantt Chart