Greenhouse for an indigenous community in Barriere Lake

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Abstract

This report summarizes the entire design process for the greenhouse project prepared for our client Monique Manatch who comes from a remote aboriginal community up north called Le Domaine. By following the design process, this report details the initial research, prototyping, testing and final result of the product. Furthermore, it includes the lesson learned and recommendations on improvement needed in order to construct a better design for future work.

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1. Introduction

1.1 The Problem

The greenhouse construction is a joint project between the University of Ottawa and the client Monique Manatch who comes from the aboriginal community of Le Domaine. Le Domaine is an aboriginal community of that consists of roughly 50 people that lives at an abandoned airport strip off of Barriere Lake. One of the biggest inconvenience is that there are no nearby grocery stores in the community with the closest ones located in Maniwaki or Val d'Or that is hours away. The location is secluded with no electricity or running water, but there is a freshwater stream nearby. The area has a flat stable ground with very fine sand. Currently, there is a small raised farm beds for tomatoes, radishes, lettuce, and peppers. However, they have ran into problems with their farm due to small animals like mice and bugs eating the crops. Furthermore, these farm beds will not be usable during the winters resulting in no fresh source of grown food in the winter. Harsh winter climate at the location can reach a drop of -30 to -40 degrees celsius. The team at the University of Ottawa has been assigned to come up with a greenhouse solution that can help Monique and the community of Le Domaine to grow food all year around.

1.2 Basic User Requirement and Constraints

Since the location is very remote along with very harsh variable weather conditions, it is crucial to create a sturdy structure that can withstand anything it encounters. First, the greenhouse must be able to supply food year round to the community of 50 people at the residence. Specifically the food should be hardy crops such as potatoes or green vegetables. Secondly, the structure itself should be modular meaning it can be easily disassembled for transportation and moving around. Finally, the greenhouse must provide a safe food source and protect against rodents and wild animals that frequently visits the area.

1.3 Differentiation in Design

To set the greenhouse design apart from product that is already on the market, the team brainstormed ideas such as a roof that slants on an angle in one direction and raising the entire structure and putting it on top of concrete pillars at each of the corners. The slanted roof design was specifically thought out in order to handle the snow accumulation that occur frequently in the area. By slanting the roof on a specific angle, it allows snow to fall down and not build up on the roof which will ultimately block sunlight from entering the structure. Additionally, this prevents added weight on the roof which might cause a problem in the future. Once the snow or rain flows down the roof, the liquid will then enter a gutter along the roof sidings which will then fall through a tube that enters structure and be used as a natural water source for the plants and vegetables. Raising the structure and putting it on top of a concrete block was something that wasn't very common on the current market. Due to the rural condition of the location with rodents and animals, raising the structure makes it more difficult for animals to enter and sabotage the structure. Raising the structure also has the benefit of preventing permafrost to build up which will ultimately affect the internal temperature of the greenhouse.

2. Need Identification and Product Specification

2.1 Problem Statement

A need exists for us to provide an Aboriginal Community in Barriere Lake with a durable, weather resistant and hydroponic system based greenhouse that will allow them to eat produce all year long.

2.2 Benchmarking

From market research, the team has identified two products that is currently available on the market to benchmark. The first design is a simple hoop greenhouse design. Compared with similar products, this was the easiest and most economical greenhouse that you can simply build at home under a very small frame of time. Roughly the cost to product this product is around \$50 and all the material can be gathered from local home hardware stores. The structure is made out of three quarter inch PVC piping that is fastened with pipe fitting that goes around the wood frame structure. Overall structure dimension is 15×11 ft and 7.5 ft tall from the center. This design was studied due to its simplicity and the fact that the design incorporates the idea of a sloped roof to prevent the build up of snow and water which the team have taken ideas from and incorporated into the current greenhouse design.



Figure 1: Simple hoop greenhouse design (Fisher 2018)

Secondly, the team studied a more complex greenhouse design that featured a multi level sloped roof with a functioning door that opens. It contains stakes hammered into the ground to keep it stabilized and has the option to permanently be held in place if needs to be. This greenhouse is ideal for harsher weather climates which the thought it was suitable for the location of our client. This design was picked to be benchmark because the construction of the design is very aesthetically pleasing and contains multiple features that can be incorporated into our own design.



Figure 2: Multi level window greenhouse design (Fisher 2018)

2.3 Metrics & Target Specifications

List of Metrics

Service Life: By adding more hinges and switching out the current plastic film for glass will boost its service life. The construction team predict that the lifespan of the structure is roughly within 3 years.

Usability: Greenhouse was built was a modular emphasis in mind. Meaning it can be very easily dismantled for transportation or moving around at the discretion of the user. Furthermore removable steps was added in order to accommodate the house being raise and provide the support when stepping in to the house. Foldable mini shelves was installed for the client to place any small scale items along the side of the wall.

Durability: The wood used in the build creates a sturdy structure along with reinforced hinges that goes onto critical points of the connecting joints. The only component of the greenhouse that is might be at risk of a durability issue is the plastic sheeting that is wrapping around the structure. If the budget was stretched higher, glass windows should be used to strengthen the build and protect it against wild animals.

Competition: Currently, there are many similar products on the market.

Cost: The budget of the product is \$250.

Size: 6 ft x 4 ft with a height going up to 6 ft.

Time: The product is expected to be finalized by November 28, 2018. The team has approximately two months from mid September to November 28, 2018 to complete the project.

Quantity	Part Name	Individual Cost	Total Cost
4	2x6x8	\$5.40	\$21.60
30	2x3x8	\$3.65	\$109.50
1	Vent	\$7.49	\$7.49
1	Solar Panel	Supplied by uOttawa	Free
1	Polyethylene Sheets	\$52.97	\$52.97
1	Corrugated roofing panel	\$32.97	\$32.97
1	Plywood	\$16.25	\$16.25
4	Concrete Blocks	Supplied by lab coordonator	Free
TOTAL	Х	Х	\$240.28

Cost: (Initial estimate)

Table 1: Cost breakdown

3. Conceptual Design

3.1 Prototype 1

Prototype 1 is designed from popsicle sticks to construct the general design of the greenhouse. The pieces were broken down on a smaller scale in order to represent the actual design as much as possible. The structure is held together by glue. Additionally, the blocks on four of the corners were used by paper box and the roof is covered with thin layer of plastic.



Figure 3: Prototype 1

3.1.2 Prototype testings 1

The angle of the roof was tested on prototype 1 to ensure that snow and rain would slide off the roof and into the gutter. To ensure that the angle of the roof is sloped far enough, we simulated it with water as well as some ice that builds up in our kitchen fridge.

They were then dropped on the slanted roof to test if the angle of the roof was effective. Our result validates the angle of the greenhouse roof to be adequate to be resistant to snow accumulating on the roof.

Prototype 1 confirmed that the slanted roof is effective at having snow not accumulate on the roof by sliding off. This slanted roof has remained in the design for this final prototype.

3.2 Prototype 2

In order to fully visualize the prototype, a AutoCAD 3D model was drawn out according to the design specifications. The new model prototype now featured modifications to the overall size of the green house to be 4x6 ft. Besides the modification, the greenhouse still features a door along the short side of the framework and a slanted roof along the short encouraging snow and rain falloff. The prototype design was made strictly of the wooden skeletal framework of the greenhouse structure.

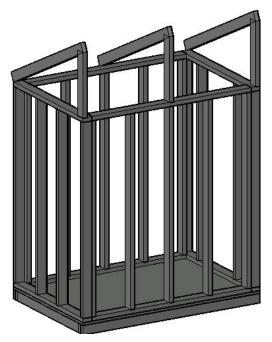


Figure 4: Prototype 2

3.2.2 Prototype testings 2

Though the AutoCad design software, the team was able to convert the CAD file into a STL file and print it using one of the 3D printers in Makerspace. This helped the team better visualize the entire structure of the greenhouse in person and be able to study the various angles as well as the change in dimension that was made after prototype 1. These changes included the extension of the greenhouse structure. The intention of the added space provided will allow any personnel to enter the structure to operate the hydroponic system installed within.

3.3 Prototype 3

Prototype 3 is a the final stage product based on the continuation of all the previous prototypes. It is a physical comprehensive prototype. Designed to be a physical working model made in the structure lab using wood, screws and nail gun to put together. The size of this prototype will be 6 ft x 4 ft with a height going up to 6 ft. This prototype will be fully functional with insulated walls, working door, and room for hydroponic system to grow vegetables. This prototype used various pieces of 2x4 wood for the structure, a ³/₄ plywood for the flooring and plastic wrapping in substitute for plexiglass.

3.4 Client Feedback and validation

Client feedback and their approval is one of the most important components of this project. As this project was geared toward one client, it was important the client knew exactly what is going on at each stage of the project and give constant review to the team. Such that, the construction team utilized the valuable with the client as much as possible to get as much response as possible in order improve future design. For the duration of this project, the team noted down addition as well as things to take out during each prototype meeting. Since the first prototype was presented to the client, the team has received mostly very positive feedbacks from the client. Her constructive feedback motivated the team to go in the right direction to satisfy the client need as much as possible and creating a product that she will enjoy in the end. The final completed prototype is a build up of all the client feedback with added touches from the design team.

4. Project Planning and Feasibility Study

4.1 Design Process

Design thinking process was applied to this project to have a series of organized steps to create the best solution and implement it. This was the suitable choice as the greenhouse was specifically for one client that required the ability to produce food throughout the year in a rural environment.

Throughout the project, empathy played a big role when developing the product as the client who needed the convenience of fresh produce in such as isolated community. The best way to develop a product for the client was to be able understand the barriers and difficulties the client had to work in order to buy something as simple as getting vegetables. Understanding what the client struggled with was not an easy task as a lot of time was dedicated to research about various greenhouse projects that was affordable. The group members sat down and put themselves in the shoe of the client by thinking about the features of a greenhouse that would be convenient to build use and set up. During the process of designing the prototype, all the features in the prototype was geared towards minimalism and functional use. This helped the team define the problem statement and user constraints.

5. Final Project

To reach the final stage of the building and finish the greenhouse, multiple design has been considered and various iterations were applied in order to reach the solutions. The final design reached using previous prototypes as a stepping stone in order to perfect the product. Various outside resources such as hand sketching, popsicle sticks as well software like AutoCad contributed to the success on building up to the final prototype. This final prototype include all the components and adjustment made throughout the semester and have taken into consideration all previous mistakes.The structure is designed with a modular theme for easy accessing and removal. More importantly, joints and connection points were implemented clearly so the user can easily identify what is needed in order to disassemble.

For the design part, contrary to what the team initially planned, the final finished product features a size of 6 ft x 4 ft with a height going up to 6ft. During the building stage, the team realized the initial size of the original sketch being made into an actual structure was a lot smaller than expected. The extension of the house makes the overall aesthetics look better and create more storage room for the hypotonic team to put in their system and have enough space for the construction team to make space for the client to grow their produce. Furthermore, lab coordinator had a discussion with the team was regarding the design of the roof. The final design implements a roof that only slants on the one side instead of a triangle shaped design. As the one of the main theme of this build was simplicity, the team decided that this design provided the necessary function needed to clear the snow and liquid accumulation in the winter at the same time be easier to install and remove for the user as well as anyone who needs to transport it. The overall building was then wrapped in plastic sheeting to cover all openings to implement the idea of keeping the produce inside at a normalized temperature. With more time and more usable material, the team would like install glass panels and add in electric heating system inside the building that is powered by the solar panel to keep the produce alive during the harsh winter climates. Next, a door with a locking mechanism was installed to add extra security to the greenhouse and keeping it away from animals. If needed, the client can further add a metal lock on top of the mechanism the team already installed for a more secure structure. Finally, the final prototype was moved and raised using four concrete pillars. The concrete pillars are inserted in the four corners of the greenhouse. The strong and durable concrete blocks provided by the University can withhold added weight up to multiple people and prevent permafrost that occur frequently at the location. A portable stepping system is put right under the front door to allow easy access to step into the greenhouse. To wrap the overall design, the team finished the construction by painting the University of Ottawa's classic burgundy colour to show off the school pride.



Figure 5: Final Prototype

6. Future Work, Lessons learned and Conclusion

6.1 Lessons learned

Many lessons were learned during the design project. First, the importance of planning in the process of developing a product. The biggest challenge encountered during the project was translating the theoretical design into the actual physical engineering design. Even though various prototypes and detailed drawings were made to prepare for actual construction it was still difficult and many changes were made. The more detail that were in the drawings and prototypes the easier the construction for that specific part was in the final product.

Another lesson learned was that complex designs are very difficult in the construction process. A complex design that isn't in the conventional rectangle shapes can add around twice the amount of work. Unnecessarily complicated designs can also add more possible mistakes in the construction process. Overall the importance of practicality is greater over the aesthetics.

Finally, organization played a huge role in order to be prepared and organized for the task at hand. A lot of time spent in the construction of the greenhouse was spent looking for correct tools and gathering supplies. Having an organized set up with all the tools ready and an exact plan of what to do would greatly excel the time management during the construction process.

6.2 Recommendation for future work

Recommendations for a future design would be to have greater planning in the theoretical design process before commencing construction. This would include precise drawings showing exact layout of all supports of the greenhouse. The more time spent preparing and planning the easier and simpler the construction will be with less errors and spontaneous changes.

Another change for future work would be being more prepared with equipment of having the right tools and materials available would greatly reduce time wasted searching for them.

Having a detailed schedule of what specifically needs to be worked on with detailed instructions of the construction process would increase productivity and reduce possible mistakes during the design process.

The overall design of the greenhouse would remain the same as the design is effective and efficient. However superior materials would be used to give a better performance of the greenhouse.

6.3 Conclusion

Overall, the build of this project was successful and reflected the skills and techniques taught from the lecture. The product was completed in time for design day and have potential future use for the client. Furthermore, the project created bonds between group members and utilized the team cooperation concept in order to reach a common goal. The construction team started out as strangers, but bonded throughout the semester to be good friends. This course as well as the build of this project definitely give students an advantage when encountering future design problems or similar courses.

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