# URBAGROW

**Innovation Convention Logbook**

## I. Identifying the Problem

Standard greenhouses waste obscene amounts of energy

- 40 Megajoules per 1 kg of fresh produce
  (Sims, Ralph E. ENERGY-SMART FOOD FOR PEOPLE AND CLIMATE. Food and Agriculture Organization of the United Nations, 2011)
- Glass greenhouses demand upwards of 10-20 times the amount of energy when compared to their open field counterparts
  - Almost as energy intensive as pig farming
    (Smil, Vaclav. Energy in Nature and Society: General Energetics of Complex Systems. MIT Press, 2008, page 297)
- Current educational greenhouses cost almost $1534 just to keep warm and lit.
  (Greenhouses-Energy Consumption and Equivalents, Cornell)
- The average age of a public school building in the US is 42 years old.
  - Department of Education
- We came up with the problem after visiting Meier Gardens in Grand Rapids Michigan on a cold day, where you could see heat waves emanating from the glassed in sections.

## II. Understanding the Goal

***Research***

*Hydroponics*

Sources

https://generalhydroponics.com/basic-hydroponics
https://generalhydroponics.com/floraseries
https://www.advancednutrients.com/articles/hydroponic-supplies-you-will-need-to-start-your-garden/
https://www.fullbloomgreenhouse.com/hydroponic-systems-101/
https://www.epicgardening.com/hydroponic-growing-media/
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What is the scientific basis behind hydroponics?

- Growing plants in water with no soil
- Instead they are grown in a water based, nutrient rich solution.
  - Allows roots to come into direct contact with the nutrients and oxygen
- Advantages
  - Plants grow up to 25% faster
  - Produce up to 30% more
  - They do not need to work as hard to obtain all the nutrients

- Disadvantages
    - They can be difficult to manage
        - You must monitor pH and nutrient levels on a daily basis
    - A broken pump can kill plants in a matter of hours

What equipment is needed to grow plants with hydroponics?

- Fresh Water
- Sunlight
- Nutrient Solution that contains
    - Carbon (C)
    - Oxygen (O)
    - Hydrogen (H)
    - Nitrogen (N)
    - Phosphorus (P)
    - Potassium (K)
    - Calcium (Ca)
    - Magnesium (Mg)
    - Sulfur (S)
    - Iron (F)
    - Manganese (Mn)
    - Zinc (Zn)
    - Copper (Cu)
    - Boron (B)
    - Molybdenum (Mb)
    - Chlorine (Cl)
- A growing medium
    - Merely the support for the plants, they use different types of Hydroponic Media to support their roots and maintain a good water/oxygen ratio
    - Coco Peat / Coco Coir
        - Made from ground up coconut husks
        - Pros
            - Hormone Rich
            - Fungus Free
            - Assists in Germination
            - Great air to water ratio
            - Was a waste product
        - Cons
            - Holds a lot of water and could drown plants
- There are different types of systems and each have different setups

- Deep-water Culture
    - Reservoir method
    - Roots are suspended in a nutrient solution
    - An air pump oxygenates the nutrient solution
    - Pros
        - No drip / spray emitters to clog
    - Cons
        - Reservoir if not covered can grow algae in it and wreak havoc
- Aeroponics
    - Roots are misted with nutrient solution while suspended in the air
    - Two methods
        - Fine spray nozzles to mist the roots
        - Pond Fogger
    - Existing Product
        - Aero Garden
- Nutrient Film Technique
    - Continuous flow of nutrient solution that run over the plant roots
        - Uses gravity to maintain the flow of nutrient solution
        - Because only the tips of the roots get the nutrients the plant can get much more oxygen
- Wicking
    - Wicks (cotton) transfer the solution directly to the roots
    - Growing mediums can also wick to the roots
    - Very low cost
- Ebb and Flow
    - Flood and drain
    - Used for plants that need some "dry time" to let their root systems expand.
    - Uses a timer to flood the system which then drains into the reservoir
    - Expensive and generally ineffective for smaller crops
- Drip System
    - Provides a slow feed of nutrient solution to the hydroponic medium
        - Needs a "slow draining" medium
    - Drippers/Emitters are famous for clogging - particles clog up the nozzle.

Plants for Testing

https://fastplants.org/product/standard-wisconsin-fast-plants/

*Greenhouse Research*

https://vergepermaculture.ca/2014/11/06/passive-solar-greenhouse-design/

- Oriented slightly to the east (integrate a compass)

- 70% transmissivity glass is what you want.
    - As you increase transmissivity, the r value declines
    - 72% transmissivity with an r value of 2
    - Angle of the greenhouse roof
    - Slope is south facing and as a rule of thumb should be the latitude plus 10°
        - 42.3 + 10 = 52.3
    - Insulate
    - R20 insulation used in the "canadian prairies" (Michigan)
- Ventilation
    - Ventilation area AT LEAST 30% of the glazed area
        - Have ways to increase ventilation but keep temps under 79F
- Irrigation
    - Will be done using hydroponics
- Thermal Mass (heat Collection system)
    - Heats up in the day
    - Releases heat in the night

Foundations are a crucial component that dictates the success of any building. It is a component and we often don't think about it, yet a ton of energy goes into the design and construction of a foundation. There are literally enough foundation options out there to write about them for years so I am going to stick to my top 3 options, but first let's start with a few principles specific to greenhouses.

Option 1) The first foundation that I am a big fan of is frost protected shallow foundations. These are strip footings with an insulated stem wall and a horizontal projection of insulation. This allows plants to express the roots, prevents the frost in and does restrict what you do in the soil going forward. This type of greenhouse can grow trees, seedlings or microgreens.

https://medium.com/@rob_74123/how-to-design-a-passive-solar-greenhouse-part-2-of-4-e41471ab06e0

*Design Constraints*

- Our product must:
    - Keep plants at a survivable Temperature (above 55 F)
        - Insulate everything but the south side + the bottom)
        - Use Thermal Mass
        - Maximize Natural Ventilation
    - Be able to be carried by 2 people person (80 lbs Max)
    - Fit on a small balcony area (3x3 foot base)
    - Be Cheaper than existing solutions

- Be Easily Monitorable / Sustainable (almost turnkey)
- Be Easily Marketable (target audience identified, able/willing to buy)
- Use Less energy than conventional greenhouses
- Be able to link up with other modules to form larger greenhouses

*Possible Solutions*

- Possible
  - Passive Solar Greenhouse
  - Window Planters w/ heat masses to release heat during the winter
  - Skylight systems
- Selected solution
  - We decided to pursue the solar-heated greenhouse as a way to cut down on the energy needed to grow especially in a smaller area.

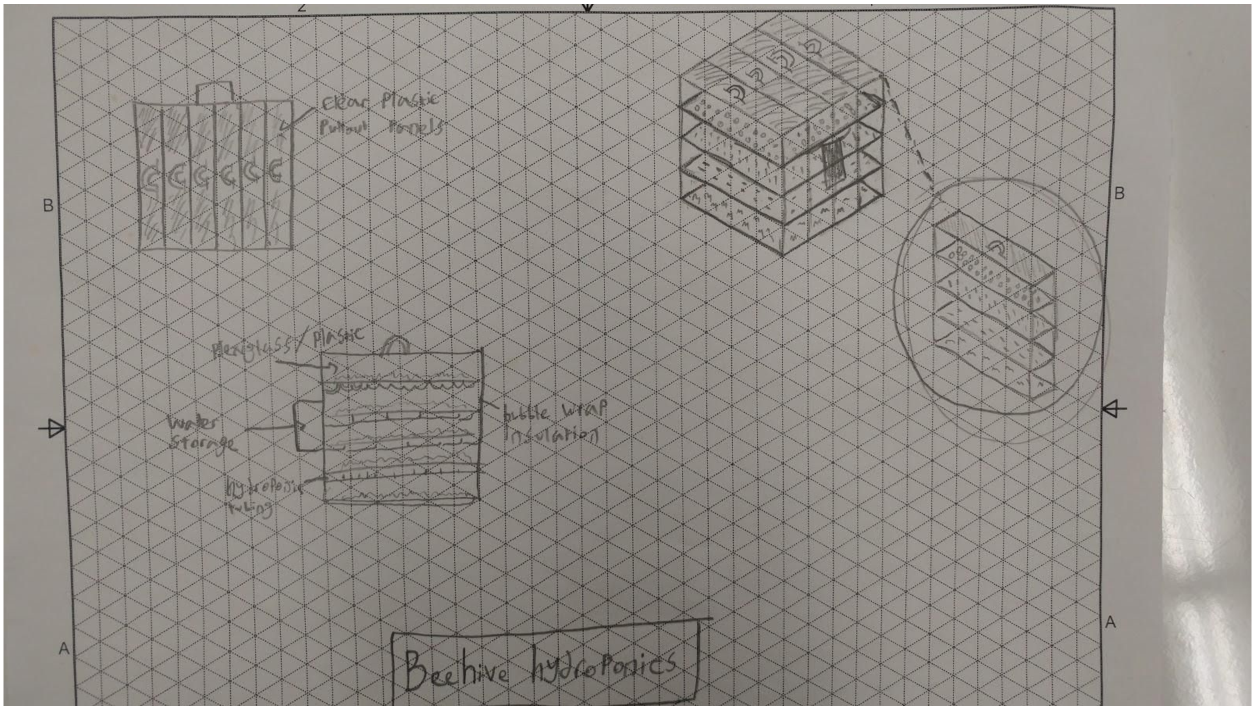
*Originality*

Where I looked to see if my idea is new:

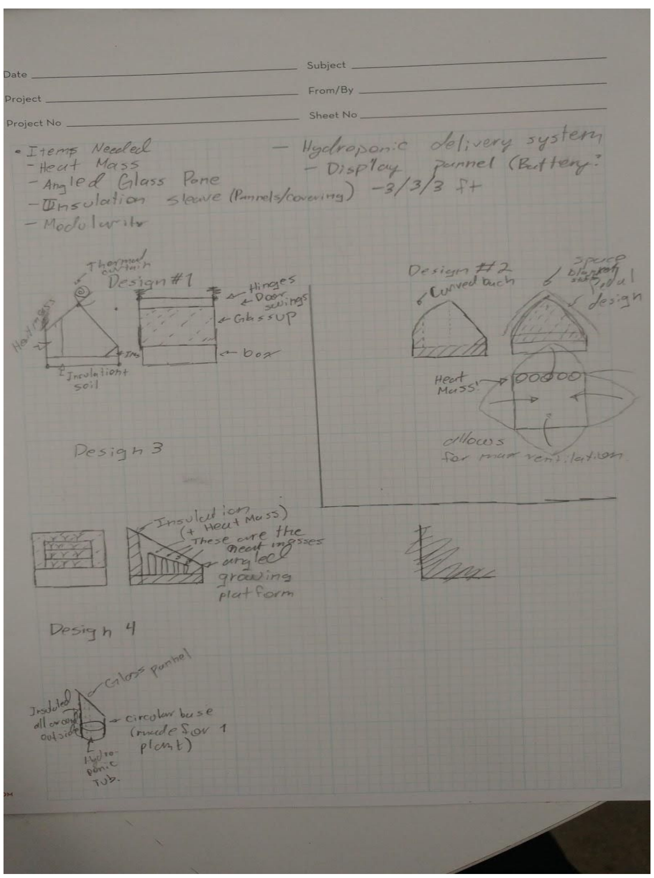
a. Google
   i. Many universities and companies have published guides and their own case studies in building passive greenhouses.
   ii. However, all were designed for a much larger scale than our urban vision, i.e. they were a lot bigger and built for more open areas
b. US Patent and Trademark Office
   i. We were able to find many examples of solar greenhouses but none specifically geared toward modularity and a smaller physical footprint.
   ii. Most were designed as walk-in greenhouse replacements, not smaller planters geared towards education and urban environments

## III. Designing a Solution

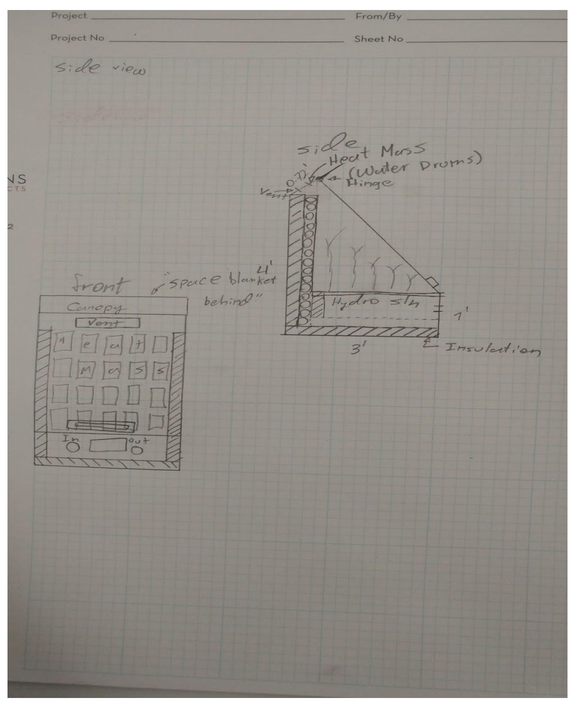
## *Concepts*



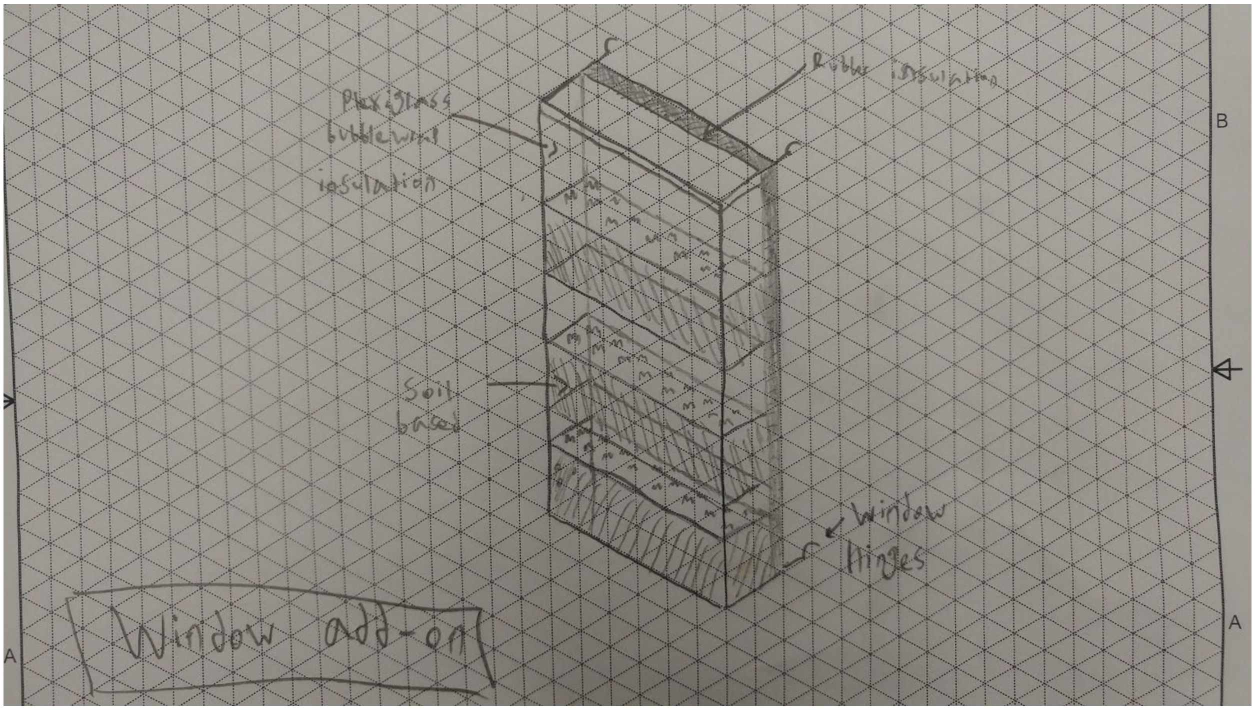
Clear Plastic
Pullout Panels
Plexiglass/Plastic
Water Storage
bubble wrap insulation
Hydroponic tubing
Beehive hydroponics

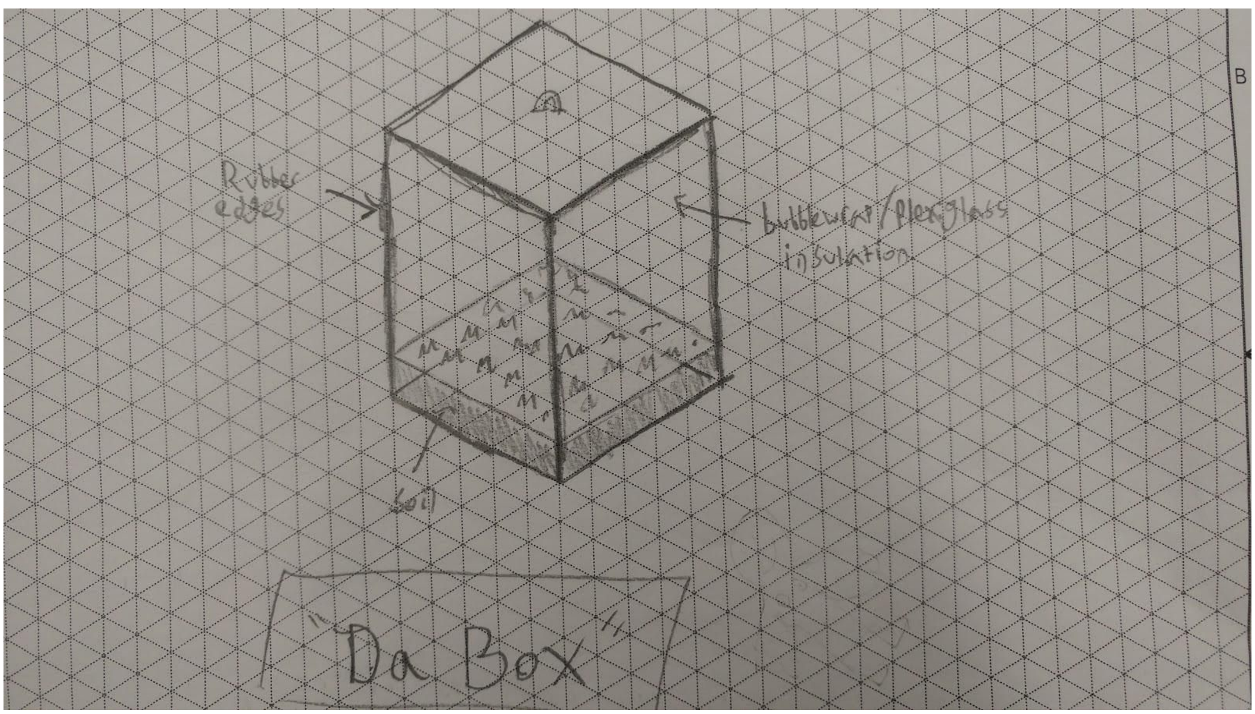



Date
Subject
Project
From/By
Project No
Sheet No
• Items Needed
- Heat Mass
- Angled Glass Pane
- Insulation sleeve (Panels/covering)
- Modularity
- Hydroponic delivery system
- Display pannel (Battery?
-3/3/3 ft
Design #1
Thermal curtain
Hinges
Door swings
Glass UP
box
Insulation
soil
Design #2
Curved arch
Design 3
Heat Mass
allows for more ventilation
Insulation (+ Heat Mass)
These are the heat masses
angled growing platform
Design 4
Glass pannel
Insulated all around outside
circular base (made for 1 plant)
Hydroponic tub.

Project
From/By
Project No
Sheet No
Side view
Side
Heat Mass (Water Drums)
Hinge
Vent
4'
front
space blanket behind
Canopy
Vent
Hydro sln
1'
3'
Insulation
In
out




***Final Design***

The Pentagon!

**<u>Justification</u>: This is the most simple design to build while still being innovative and different from existing solutions. Many of the materials required for it, we already have access to and the price of those materials is fairly low.**

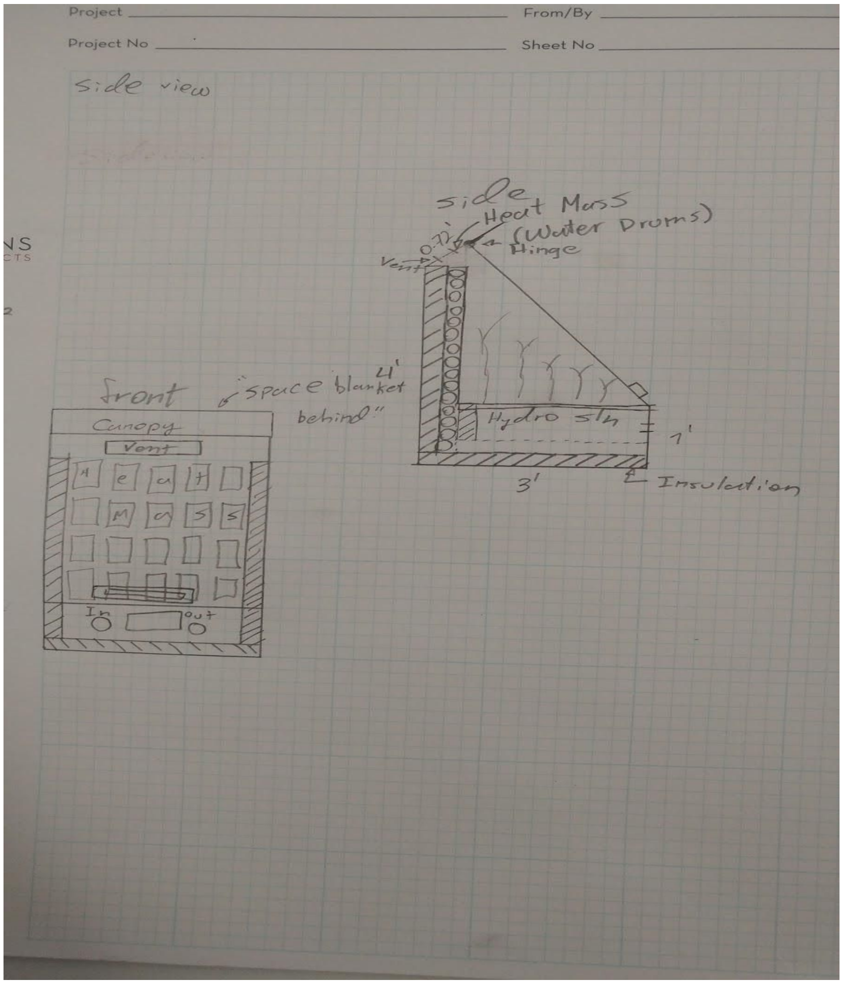
**Additionally, this design is one that we have seen across our research that works and was recommended to innovate.**

***What issues may arise?***

This machine acts as an angled box. It uses a stillwater hydroponic base filled with nutrients which is below a wood stand where the plants will be supported. Black water tanks will be placed in the back end and used as heat mass to store heat from the sun. An angled plexiglass and bubble wrap panel will be placed on the slanted side to ensure that sunlight reaches the plants to both light them and heat them without overheating them in the intense heights of noon and sunset. W20 will then be layered around the outside to keep heat inside the container. A hinged space blanket will be draped over the window during the night to keep heat in during the coldest hours of the 24 hour day cycle.

***How can we address these issues?***

We decided to follow our peer's advice. We scaled down the model to half size. This improved all of our criteria as a whole. It made it cheaper as it used less materials. It made it more sustainable as it had less area to insulate. It made it more modular as it was smaller and thus, lighter to carry




## IV. Testing & Evaluating the Device

## V. Communicating the Results

## VI. Daily Reports

***Week 0:***

*January 31, 2020*

Today Zolan and I created our problem statement and our first progress check which was approved by our instructor. Our progress check was shared between us and became our goals for the week.

***Week 1:***
**Progress Check**

| **PC1** | **F** | **M** | **T** | **W** | **T** | **F** |
|---|---|---|---|---|---|---|
| Hydroponics Research | x | x | x | | | |
| Talk to primary sources | | x | | | | |
| Online Research | x | x | | | | |
| Passive Greenhouse research | | x | x | | | |
| Online insulation/General research | | x | | | | |
| Design Constraints | | x | x | | | |
| Paper (final Design) | | | | x | | |
| Design Concepts | | | x | x | | |
| Parts List | | | | | x | |
| Final Design | | | | x | x | |
| Cardboard Mockup | | | | | x | |
| N/A | | | | | | |

*February 3, 2020*

Today was full of research. We collaborated by pulling different sources

*February 4, 2020*

Today was spent looking at different problems faced by society today. We pulled from websites as well as peers who had issues they wanted taken care of.

*February 4, 2020*

This day was spent on research beyond just websites. Joey and I looked into different patents of existing greenhouses, analyzing problems and things we liked with each model we researched. We also researched where to get parts and created a parts list so we could know what materials were needed to build the full product and where to get these materials.

*February 5, 2020*

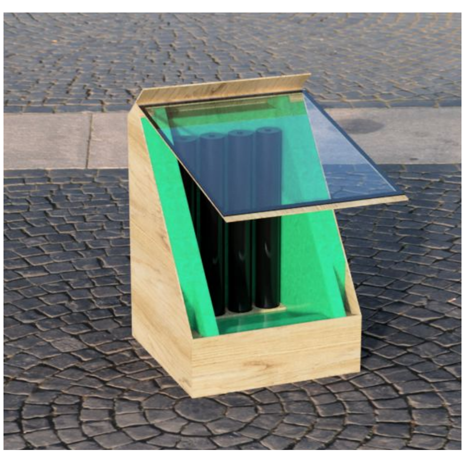
We used today to come up with constraints for our product. We decided on modularity, affordability and sustainability to be our top three concerns. We also created a cardboard mockup of our first prototype to get an idea for what we wanted our product to look like.

*February 6, 2020*

Progress Checks!

***Week 2:***

| Progress Check #2 | F | M | T | W | T |
|---|---|---|---|---|---|
| Poster Resources | | | **x** | | **x** |
| Pre-Emptive Resources | | | **x** | | |
| Journey Process Resources | | | | | |
| Poster Assembled | | | | | |
| ½ Scale Model CAD | **x** | **x** | | | |
| CAD Rendered | | **x** | | | |
| Wooden Frame Cut + Assembled | | **x** | **x** | **x** | **x** |
| Plan Video points / script | | | | | **x** |
| Film Video | | | | | |
| Edit Video | | | | | |
| Update Logbook | **x** | **x** | **x** | **x** | **x** |



*February 10, 2020*

Today was mostly spent working on CAD to finalize how everything works together. Joey cleaned up the CAD and rendered it after school and Zolan worked on our parts list and pricing for different parts. General price of around 50$

*February 11, 2020*

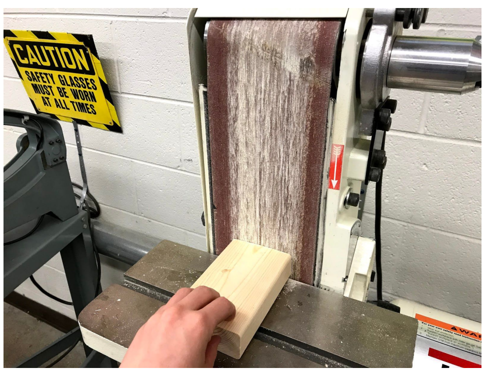
Took inventory of the wood we were able to get from our houses and modified two of our support beams to fit the wood that we had (Instead of a 2x4 we used a 1x6) It is slightly warped but that should not be an issue. Joey is going to adjust the CAD today after school and the two of us are going to head out to

Home Depot to buy birch siding for our exterior and more 1x6 wood to fit on our base.

- Home Depot Shopping List
  - 1x5 pieces of wood
  - 0.125” thick birch wood
  - Wood Screws
  - Look at their acrylics and glass

*February 12, 2020*

After getting our wood yesterday, we cut out our base and beams using a table saw and a bandsaw. We cut each to their specified length and sanded rough edges to prevent splinters. Setting up our equipment took time though so we did not get as much done as we wanted.


*February 13, 2020*

Attached our frame and the toppers were cut and sanded. We worked more on our video script and poster resources.

*February 14 2020*

Zolan was not here today but the day was spent making more poster resources, and working on more of the video script. Neither of us went to Home Depot to get the sides for the greenhouse so that has been tabled until monday..

Today we formatted and created the parts list that we will need for the real prototype of the module.

Parts List

- Plexiglasshttps://www.homedepot.com/s/plexiglass?NCNI-5
- Wood frame (materials from engineering room and Zolan's garage)
- Bubble Wrap (Already supplied)
- Hydroponic Nutrient Solution https://www.amazon.com/General-Hydroponics-MaxiGro-Gardening-2-2-Pound/dp/B00NQANQAC?ref_=fsclp_pl_dp_2
- Wood Pallet Base (The Home Depot)
- R20 Insulation https://www.homedepot.com/p/Owens-Corning-R-20-EcoTouch-PINK-Kraft-Faced-Fiberglass-Insulation-Roll-15-in-x-32-ft-RF50/301828172
- Water Drum for Heat Mass (Already supplied)
- 2 Door Hinges https://www.homedepot.com/p/Nostalgic-Warehouse-4-in-Antique-Brass-Ball-Tip-Heavy-Duty-Hinge-with-Square-Corners-728369/308667556
- Hot glue (supplied)
- Wood screws (supplied)
- Epoxy (Supplied)
- Wisconsin Fast Plants (Kroger)

***Week 3:***

| **Progress Check #3** | **F** | **M** | **T** | **W** | **T** |
|---|---|---|---|---|---|
| Video Script Finalized | x | x | | | |
| Wood Sides Cut + Attached | | | | | |
| Poster Complete | | x | | | |
| Find Plexiglass | | | | | |
| Video Complete | | | x | | |
| Print and Test a Heat Mass | | | | | |

*February 17, 2020*

Zolan was absent today but Joey was able to put on makeshift cardboard sides to the module to prepare for the video pitch. Joey created the poster resources, and attached them to the poster board and worked on the video script for our video pitch

*February 18, 2020*

Today we finished attaching resources to the poster and completed the video mockup module complete with heat mass, growing containers, glass frame and “space blanket.” We also completed the video pitch and this log book for invention convention.