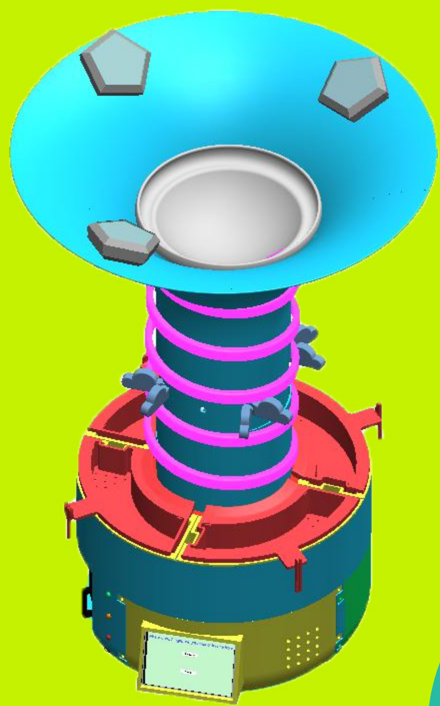

Sprout

Product Design Review

Submitted By: CP03 G22

Darren Teng **Eunice Kwok**

Mint Kewalin **Nicodemus Yim**

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Final Concept Summary: The 3Ws

WHAT

To **educate** adolescents on Singapore's susceptibility to food shocks and the importance of self-sustainability through an **engaging and convenient** form of horticulture

Engagement

An aesthetic design that **captures the user attention** and an interactive GUI that complements and value-adds to its usability

Convenience

Tackling of the pain points identified by our survey respondents during our preliminary analysis

Final Concept Summary: The 3Ws

WHO

Stakeholders involved would include the government, who will have **increased support and cooperation** from Singaporeans, educational institutions, who can benefit from a **more interactive** method of teaching and general plant enthusiasts who can grow plants from the **comforts** of their homes

Final Concept Summary: The 3Ws

WHY

Global shift towards a more **sustainable future**. Such habits are **easier inculcated from young**, which is why our target demographic comprises adolescents. Moving forward, the practice of horticulture helps achieve Singapore's **30 by 30 goal**

Previous Art

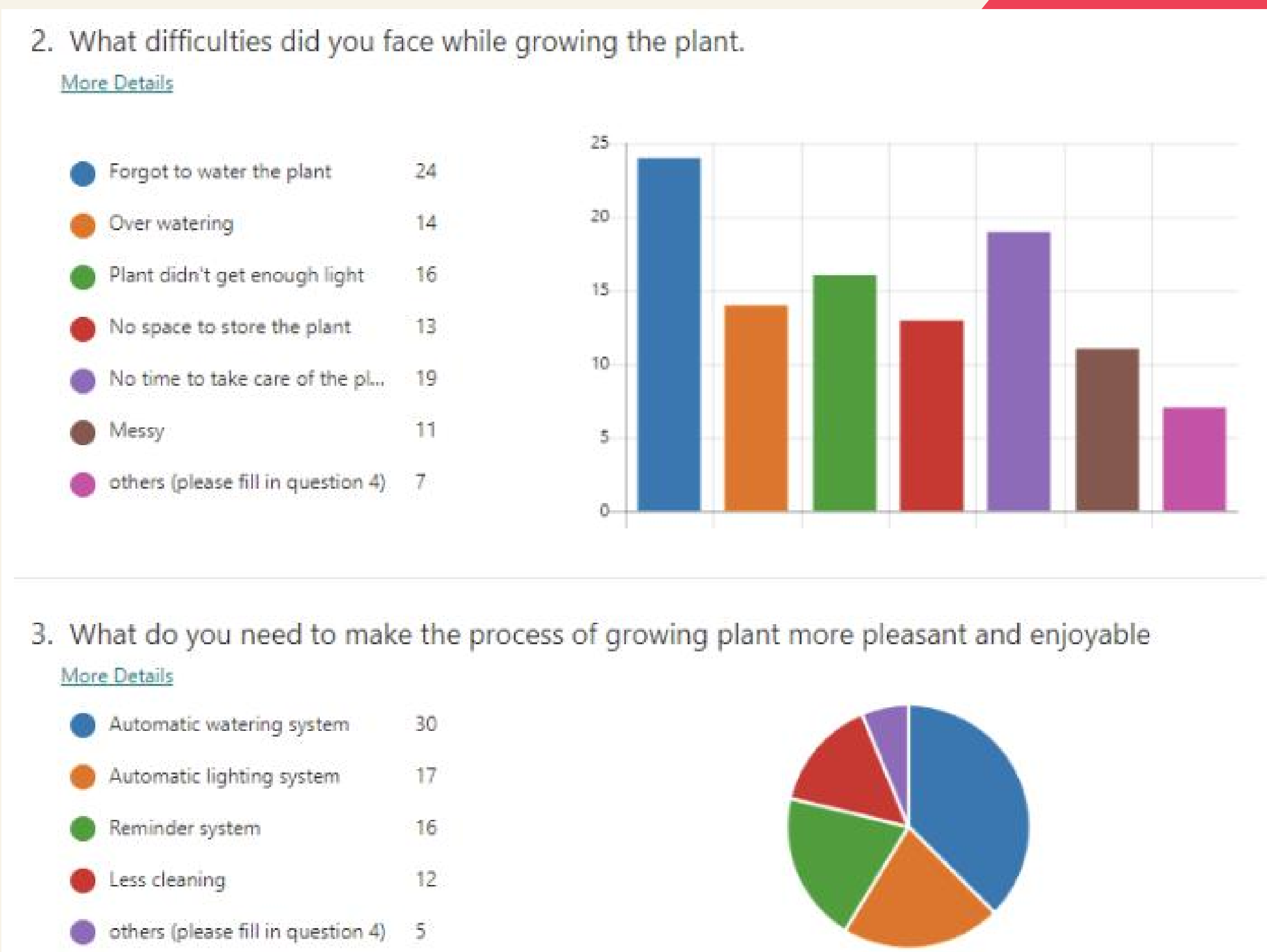
- Agri-food technologies
- Community in Bloom programme
- Eco-Stewardship Programme
- Sustainability Exhibitions
- Evident shift in educational syllabus

Limitations

- Singular focus on dissemination of knowledge

- Inadequate focus on the pain points that potential users have identified

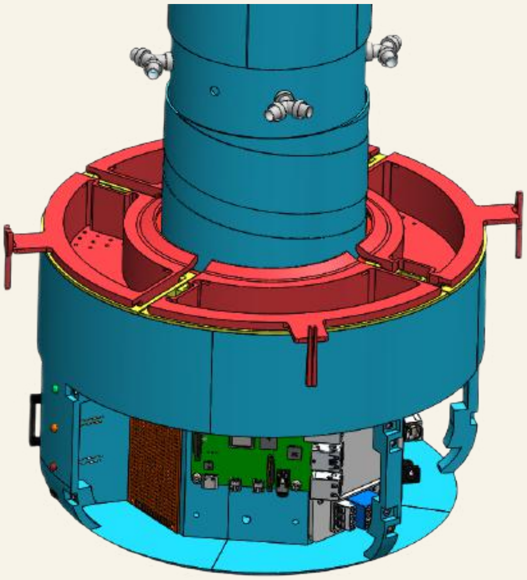
Limitations from Preliminary Analysis

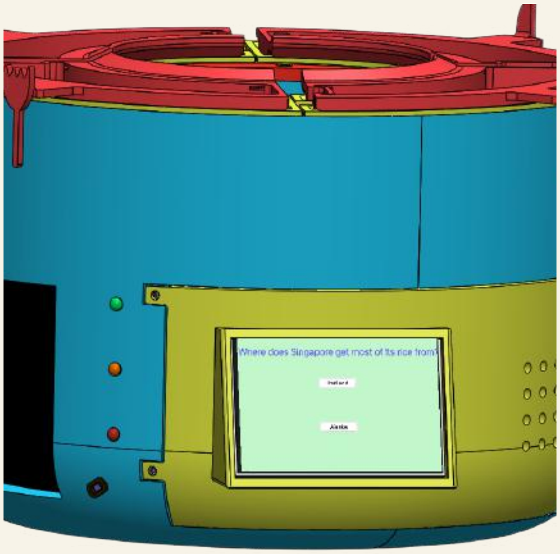


This is an important factor for our System Requirements as it would affect retention

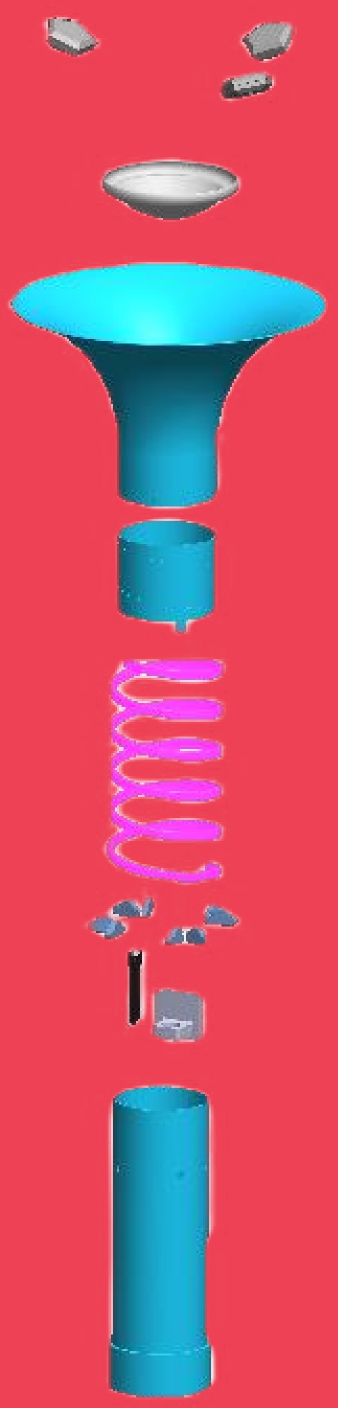
Innovation

- Integration of the previous arts to form a 2-pronged approach in ensuring sustainability and its continuity
- Resolve of user pain points that we identified in our preliminary analysis of horticulture

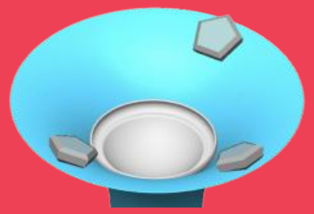




CAD

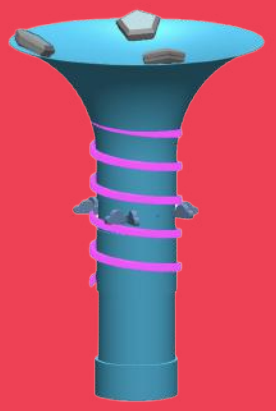


Gems
Reward System for adolescents



Caps
Prevent evaporation and spillage
Collect the gems in the event it slips down
Inspired by the Manhole Design

Funnel
Ease of refilling water
Simulate Supertree
Magnetic Strips at the top circumference
to hold the gems

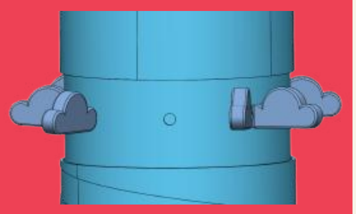


Sleeve
Indentation to assist LED light to be in place
Key and Lock mechanism to prevent the water
tank from rotating

LED Lights
Grow lights for plants

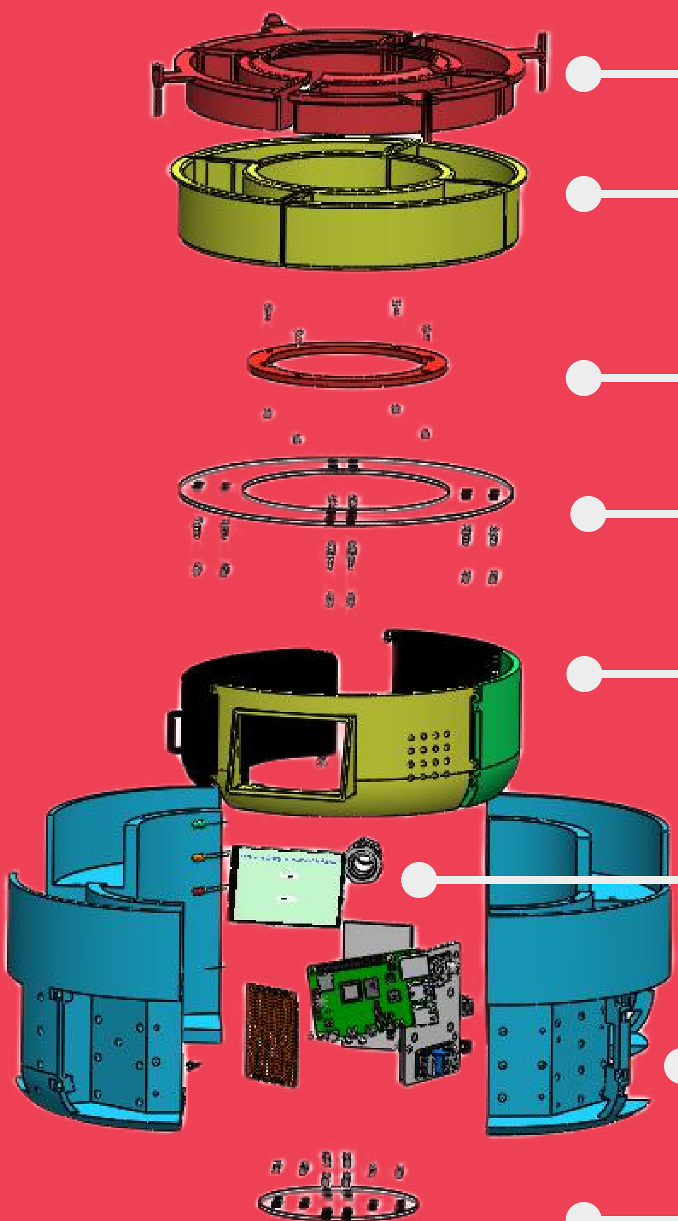
Clouds
Direct the water flow

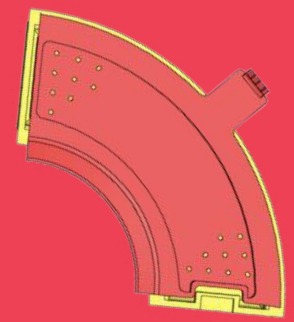
Pump and Mositure Sensor
Positioning is crucial as it prevents
overheating the pump



Water Tank
Stores water enough for whole
growth stage (12 weeks)

CAD





Plant Pots
Holes designed in this manner in account for the capillary effect

Water Basin
Collect excess water and reuse it

Wire Cap
Allow wires to reach the electronics compartment

Acrylic Piece (Top)
Secure the 4 base pieces together

Door & Drawer
Protect electronics from external environment
Ease of accessing electronics in the event of repair/ servicing

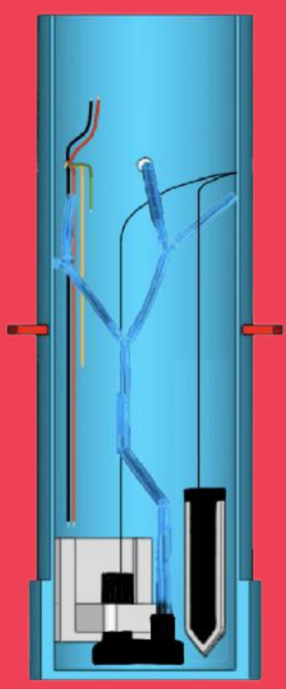
LCD
Access the quiz, online lesson videos and user manual video

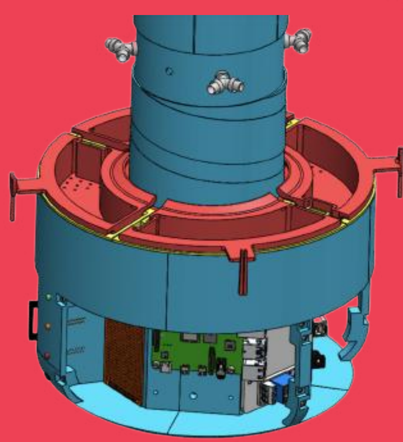
Base
Top: Pots
Bottom: drawer and electronics compartment

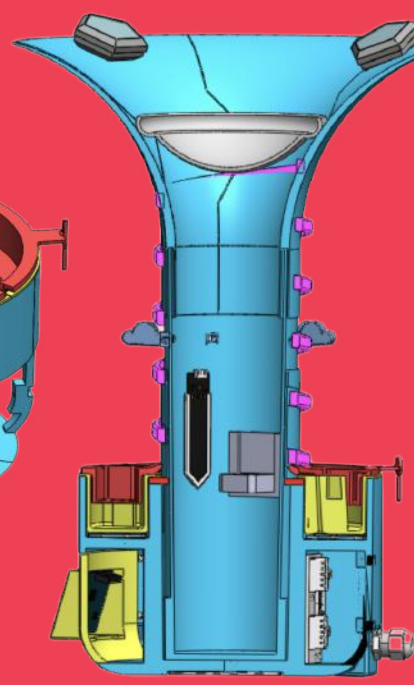
Acrylic Piece (Bottom)
Secure the 4 base pieces together

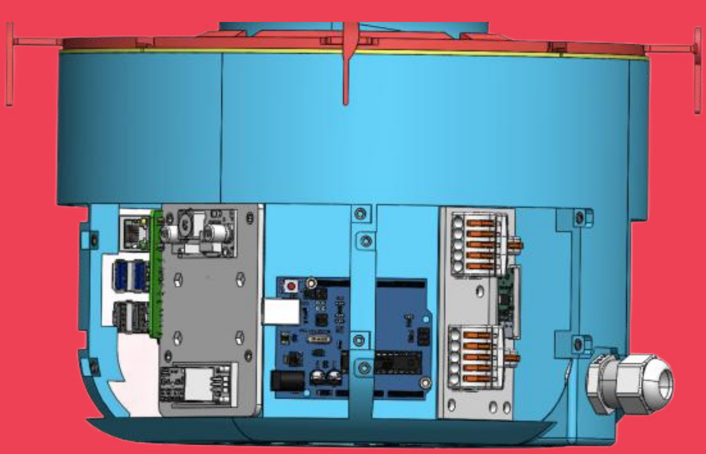
CAD

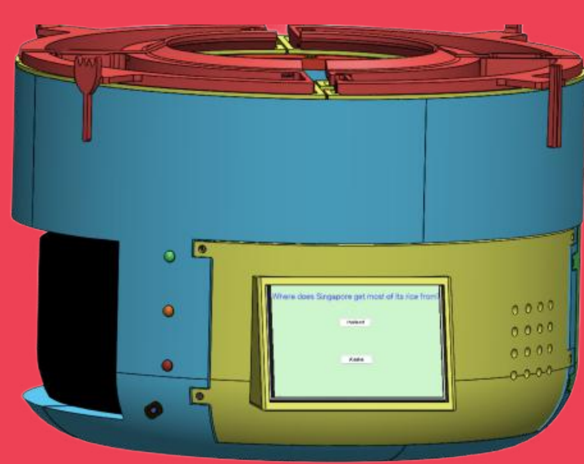
Varying Perspectives





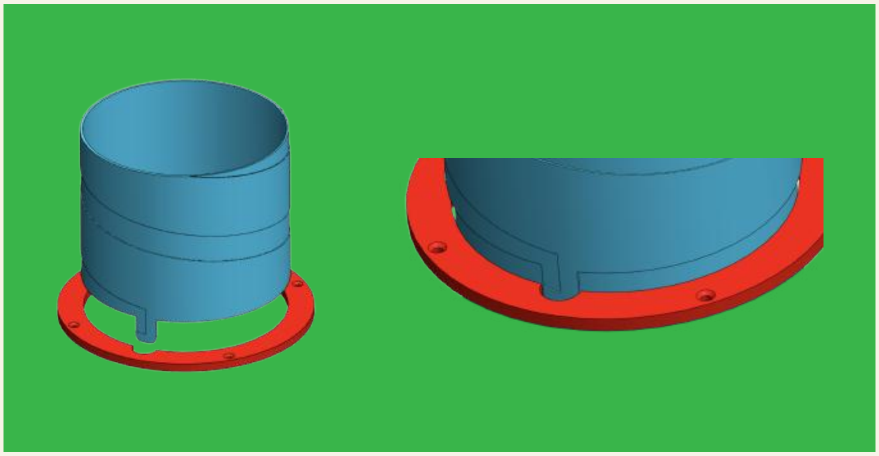




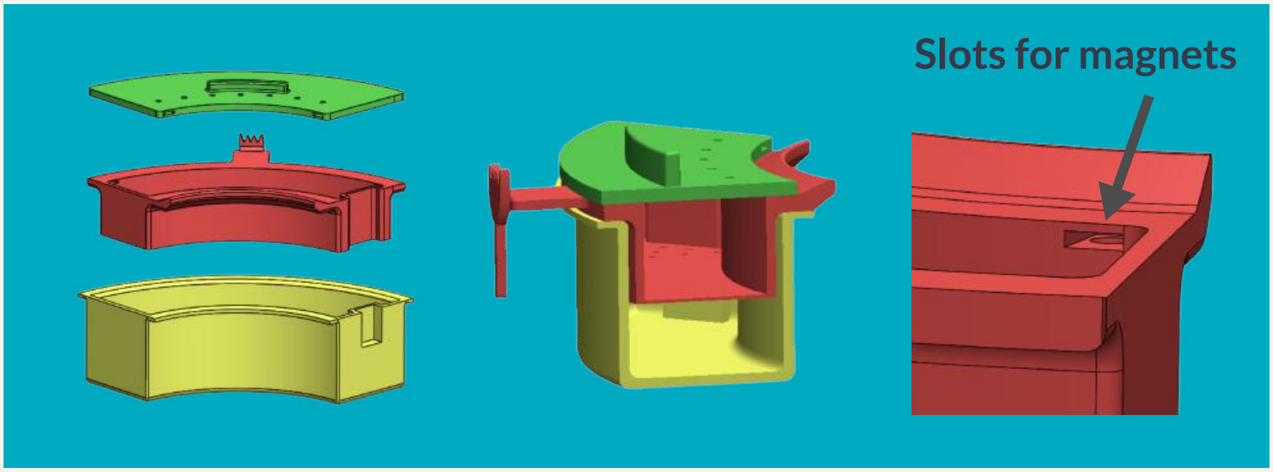


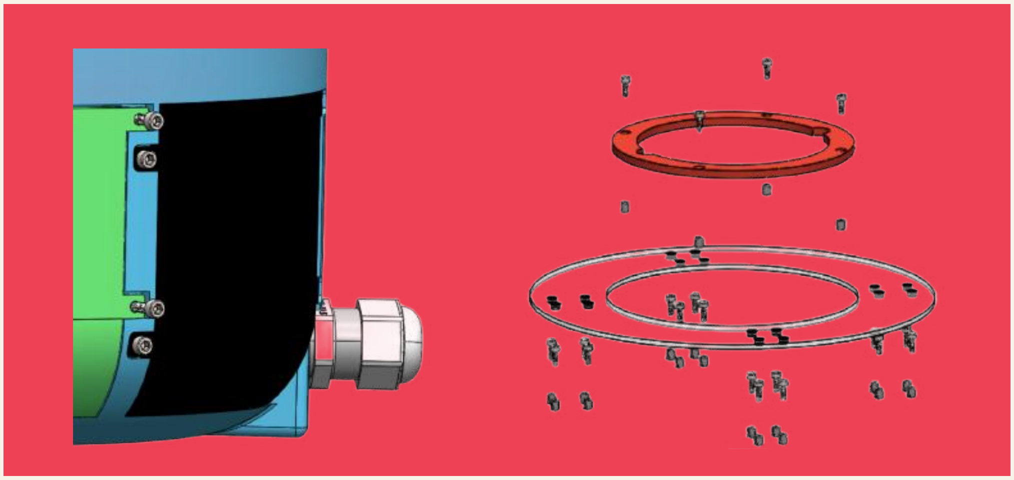
CAD

Assembling Methods



Lock and key mechanism





Screws & Insert screws

CAD: Key Features

1

Automation

Increases convenience of users and addresses the pain point of users

2

Mimicry

Visual resemblance to the iconic Singapore's Garden by the Bay SuperTree

3

Education

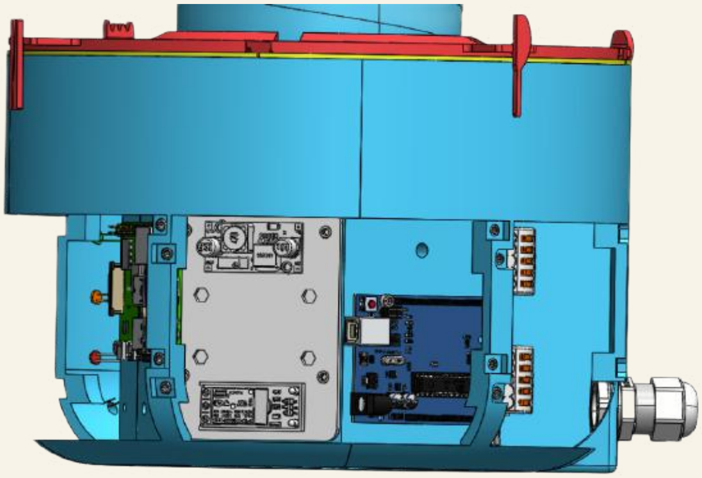
Interaction GUI that allows users to learn about sustainability and its importance in Singapore

Automation: Watering

A moisture sensor and water pump is connected to an Arduino, which periodically turns on the pump, **facilitating drip irrigation**

Exploded Image of middle section of prototype

Raspberry PI supplies Arduino with power, which functions as a microcontroller, regulating the water pump



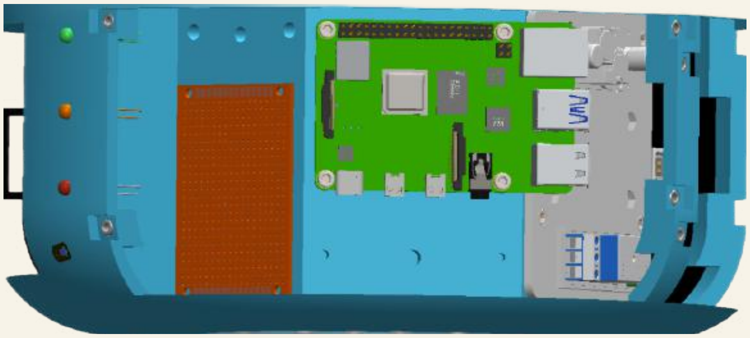
Cross sectional view of electrical component containing Raspberry Pi and Arduino, with the latter regulating the water pump

Automation: LED

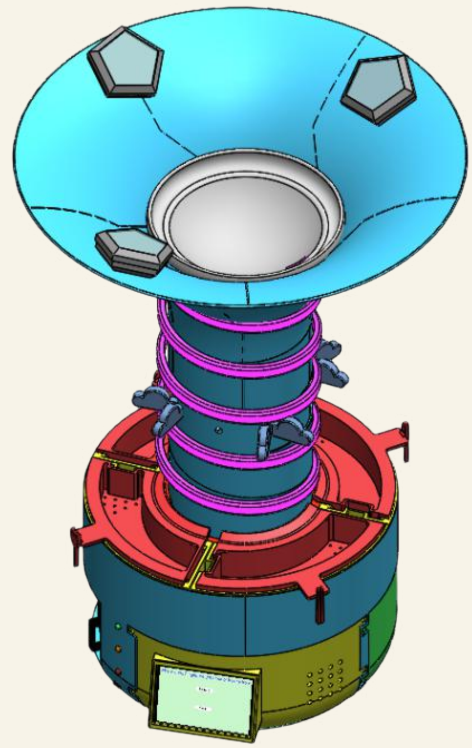
A strip of LED is wrapped around the funnel to provide the microgreens with light **<u>in absence of other light sources</u>**

Exploded Image of top section of prototype

3 different colored LED lights to **<u>reflect and alert the user of the water level</u>** in the prototype

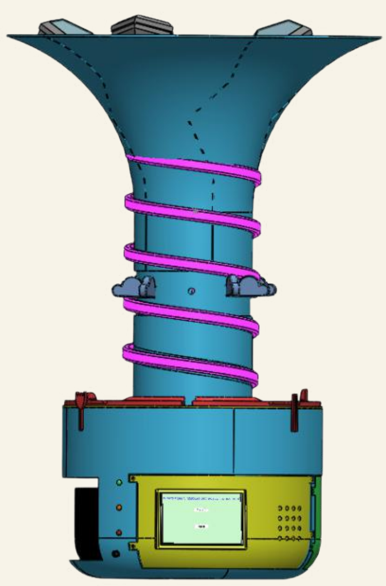


Cross sectional view of electrical component containing PERF board to power light



Mimicry

Usage of an iconic design by adopting a striking resemblance with a sustainable icon in Singapore, the Supertree in Garden's By the Bay



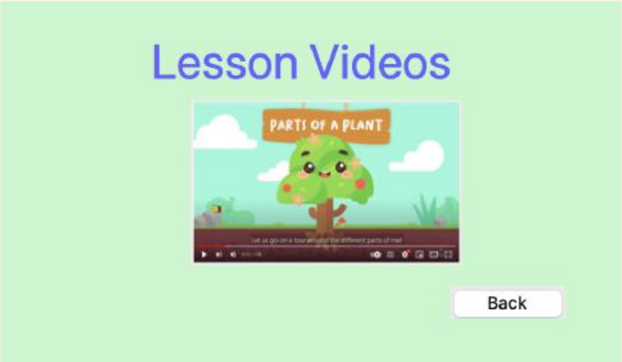
Education

Incorporation of an interactive GUI that **elevates the users' growing experience** while letting them learn about sustainability.

The education process is further enhanced with a reward system where users can earn virtual gems in the GUI and exchange them for physical ones which contain more seeds

```
class Question2(celia.Frame):
    def __init__(self, parent, controller):
        self.controller = controller
        celia.Frame.__init__(self,parent)
        canvas = Canvas(self, bg = "#CDF5CF", height = 320, width = 480, bd = 0, highligh
        canvas.pack()
        canvas.create_text(20.0,29.0, anchor='nw', text="Where does Singapore get most of
        Answer1 = ttk.Button(self, text="Thailand", command = self.CorrectAnswerUpdate)
        Answer1.place(x=200,y=100)
        Answer2 = ttk.Button(self, text="Alaska", command = lambda: controller.show_frame
        Answer2.place(x=200,y=200)

    def CorrectAnswerUpdate(self):
        page = self.controller.get_page(QuizPage1)
        page.Q2update()
        self.controller.show_frame(QuestionCorrectAnswer)
```



Requirements

Days of Autonomy

This requirement is important to improve the user experience and motivation to grow plants. The motivation behind this requirement stems from the pain points identified during our preliminary analysis.

Therefore, the duration which our prototype can work on its own without any human intervention is important as it addresses the convenience and usability of our product

Measurable Parameters

Duration that prototype can function independently must be longer than the growth time of 1 batch of microgreens

Measurables: Volume of water delivered by prototype per hour

Requirements

Attraction

This requirement is important as it is the fundamental starting point of the user experience and it determines the success of our prototype in terms of its appeal to the target audience

Therefore, the prototype must be attractive enough to not just warrant a visual interest in our prototype, but appeal to them sufficiently for a physical interaction with the prototype.

Measurable Parameters

Number of potential users must exceed 50% of the sample size used

Measurables: Number of interested users after the activation of our prototype

Requirements

Retention

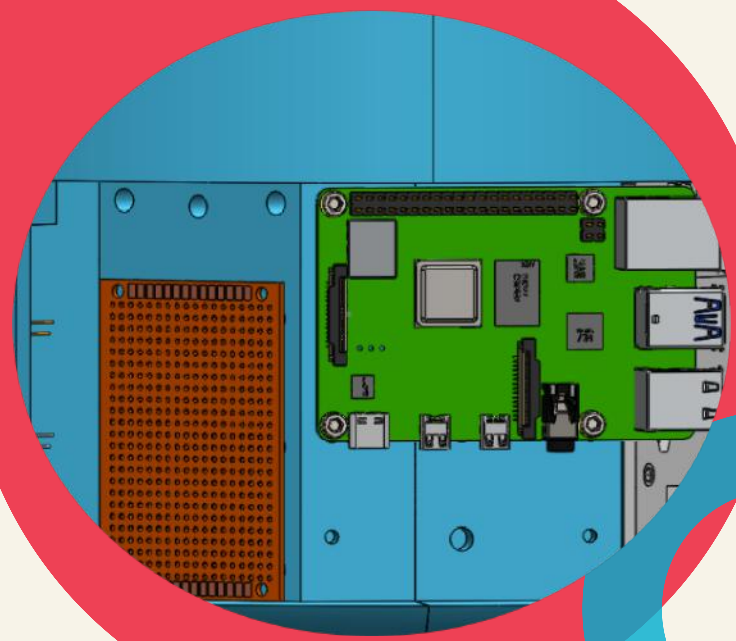
This requirement is important as it ensures the **continuity** of our prototype. Education is a long run policy and the prototype serves to be an educational toolkit that serves to address the educational aspect of sustainability.

Therefore, the prototype must be able to retain the user's interest and promote continuous usage in order for a long term policy like education to take effect

Measurable Parameters

Duration of continuous usage must exceed 15 minutes

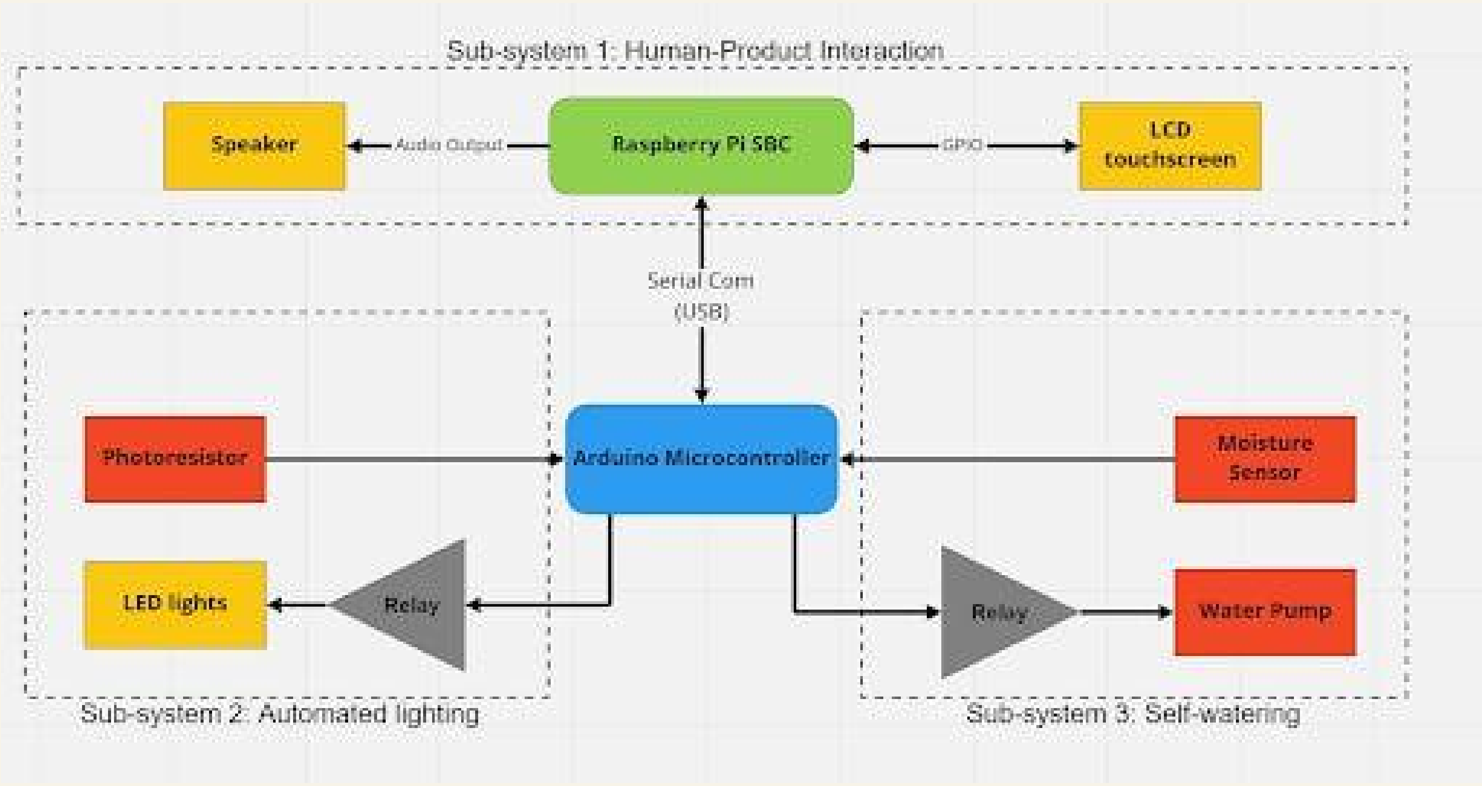
Measurables: Longest duration of continuous usage by the users

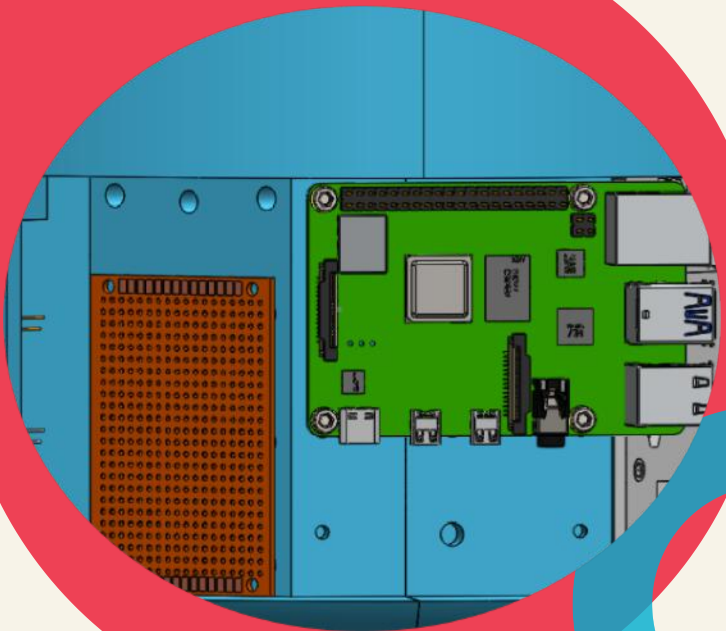


This functional diagram governs the electrical components in our prototype.

Assumptions include accurate power ratings and negligible loss during power conversion

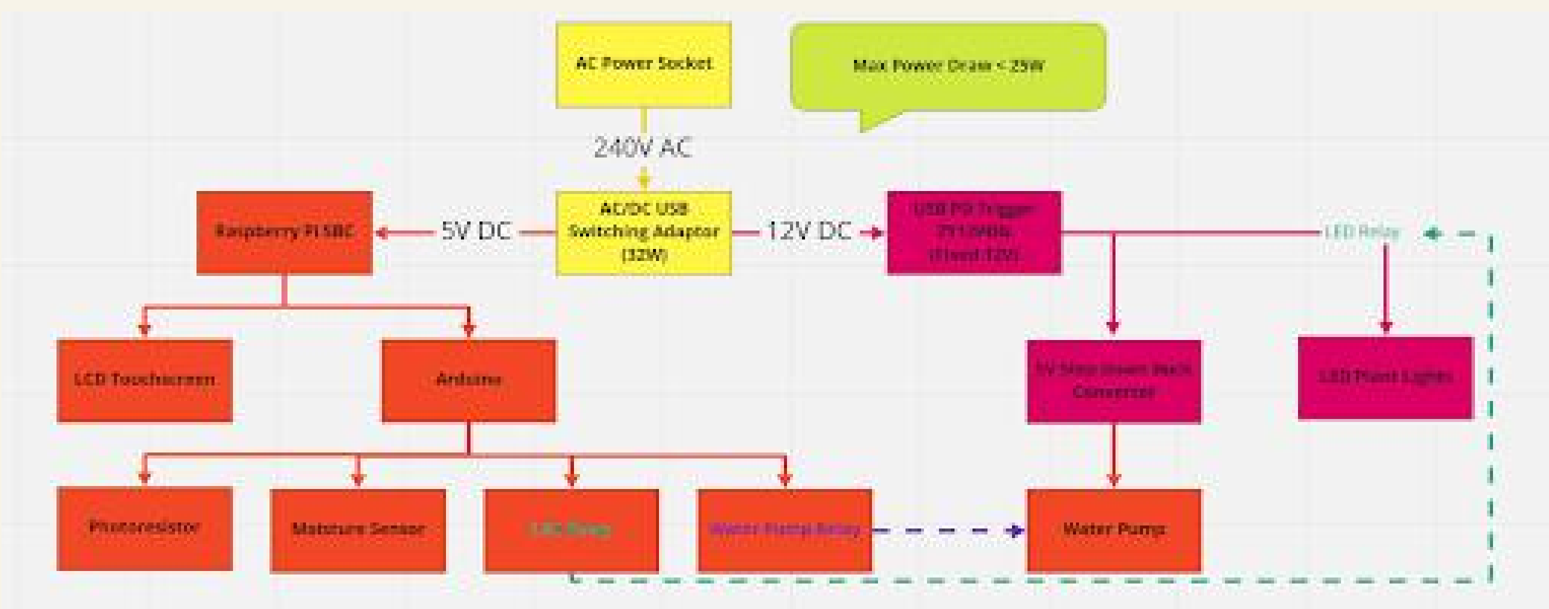
System Requirements: Functional Diagram

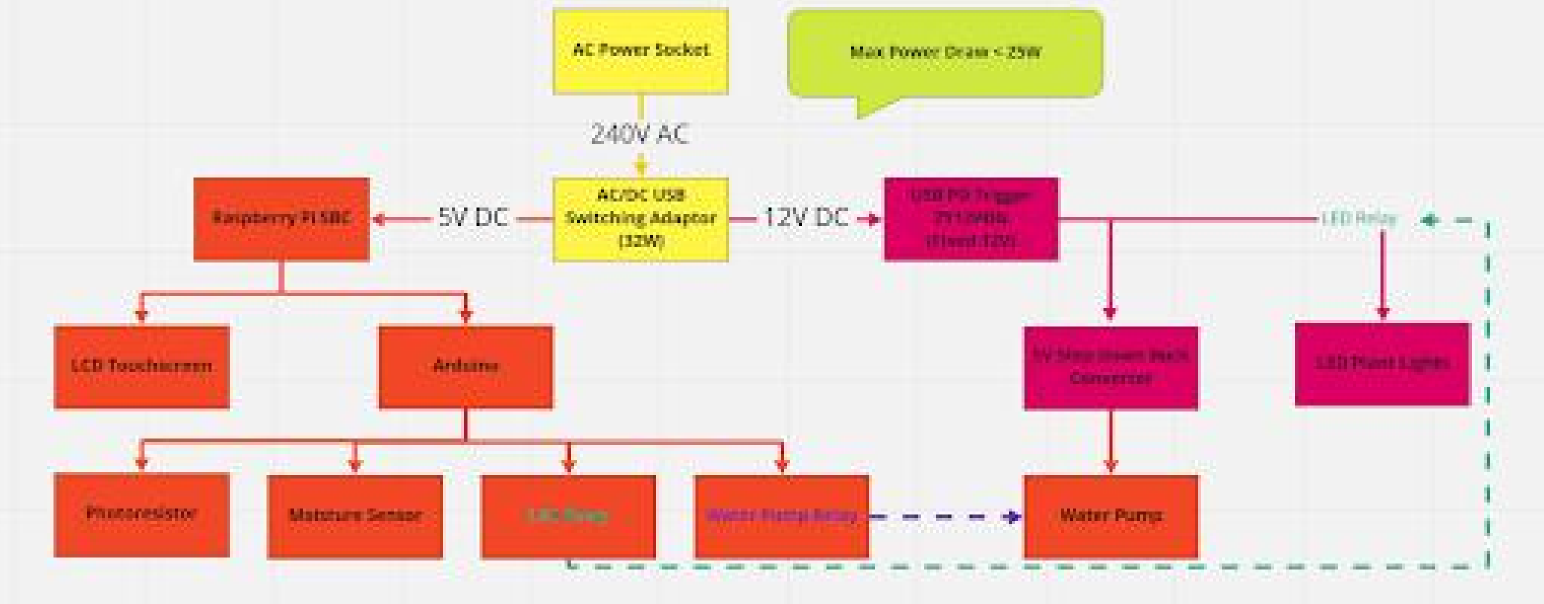




Power diagram shows a binary split of our electrical components with a 5V DC powering the Raspberry PI and a 12V DC powering the LED lights and the Water Pump

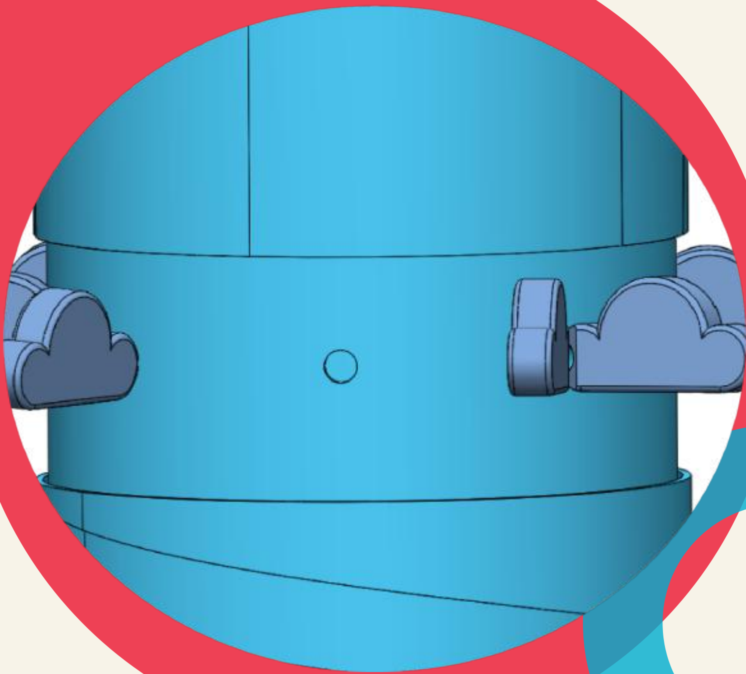
System Requirements: Power Diagram





Raspberry PI powers the LCD touchscreen and Arduino. The Arduino acts as a microcontroller to regulate the remaining 4 components

Buck Converter as an intermediary to power the water pump

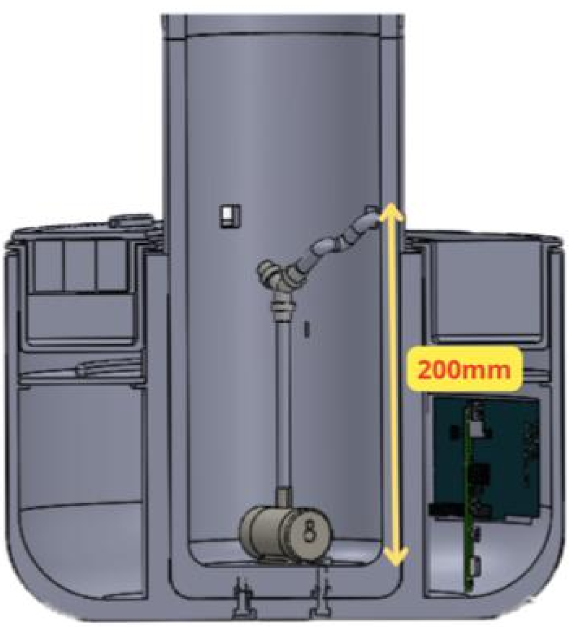


Water Flow Rate

System Requirements: Mathematical Analysis

Water Flow Rate

Context: The water pump will be placed at the base of the pipe. Water will be pumped and eventually split into 4 tubes to water the 4 plant pots.



Assuming **200ml** of water is needed **daily**, and the pump turns on every hour for 10 seconds:

$$\textit{Volume required} = \frac{200}{24X10} = 0.85\, ml/s = 8.5 * 10^{-4}\, l/s$$

$$\textit{Mass of water lifted per second} = 0.997 * 8.5 * 10^{-4} = 8.3 * 10^{-4}\, kg/s$$

Given that the h = 0.2m, assuming that water is pumped at a constant speed --> a = 0 ms-2

$$\begin{aligned}\textit{Work done by pump per second} &= F * d = m * g * h \\ &= 8.3 * 10^{-4} * 9.81 * 0.2 \\ &= 1.63 * 10^{-3}\, W\end{aligned}$$

Since the required work done by the pump is very small, any conventional pump in the market is sufficient to fulfill our needs and requirements.

Luminosity

System Requirements: Mathematical Analysis

Assumptions on lighting conditions for microgreens:

1. 20 watts per light
2. Lumens: 1700 - 2000

Source: https://www.microgreenscorner.com/microgreen-lighting-guide/

Experiment & Research Data:

1. 15 watts per light (measured using benchtop power supply)
2. $Lumens_{total} = lumens/meter \times length\ of\ LED\ strip = 1500 \times 2 = 3000\ Lumens$

   Source:
   https://www.waveformlighting.com/led-strip-lights#:~:text=A%20good%20quality%20LED%20strip,LED%20strip%20%3D%201800%20lumens).

Experimental Data

Days of autonomy

Experimental Procedures

Step 1: We grew the plants under different water conditions (10ml/30ml/50ml per day) and observed their growth.

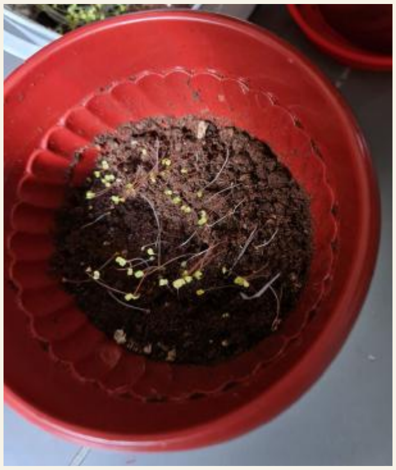
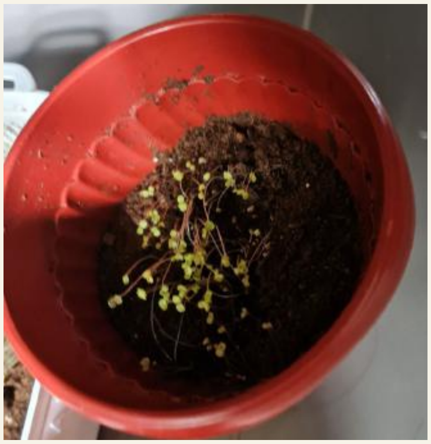
Step 2: We also grew a different plant in soil to account for the individuals who may choose to use soil instead of cocomats for their plants.

Step 3: We compared the state of the plants during their supposed harvesting stage to compare the effects of different water on their growth.

Step 4: We identified the optimal amount of water needed for the microgreens to grow and checked that our water pump is capable of delivering that amount of water.

Experimental Results

Days of autonomy

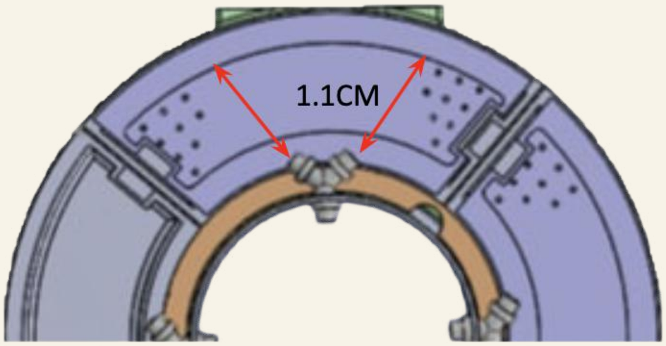

Trial Number	Amount of water released after 5 dispenses /ml	Amount of water released per dispense /ml	Amount of water dispensed in a day /ml	Amount of water dispensed to each pot per day /ml
1	100	20	160	40
2	100	20	160	40
3	95	19	152	38
4	105	21	168	42
5	100	20	160	40
6	100	20	160	40
7	110	22	176	44
8	100	20	160	40
9	90	18	144	36
10	105	21	168	42
Average	102.5	20.5	164	41

Experimental results show that the water pump can deliver 30 - 50ml of water, which is the optimal amount to water microgreens

Experimental Data

Water Dispenser UX

Experimental Procedures



Step 1: Measurements were taken to gauge what is the distance between the nozzle of the water outlet to the edge of the growing pot

Step 2: Measurements for the maximum distance the water travelled from the water outlet after turning on the water pump were taken. This was done by placing a sheet of cardboard below the water outlet and measuring the distance of the water drop stain from the outlet nozzle

Experimental Data

Water Dispenser UX

From Previous SDR

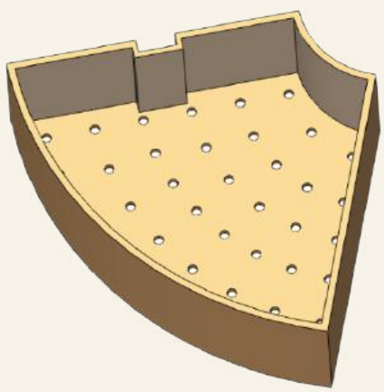
Pots were **difficult to remove** as the nozzle was positioned to close to the pots. Adjustments were made to the nozzle height but this resulted in **water spilling into the crevice** between the PVC pipe and the pot

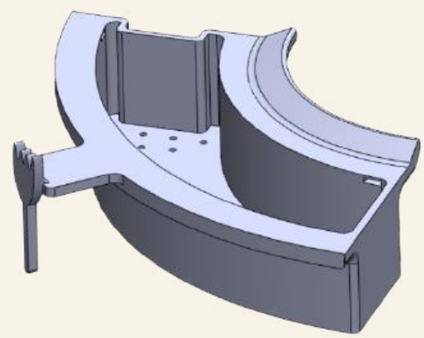
Water Outlet	Maximum Distance water travels /cm
1	0.6
2	0.9
3	0.2
4	0.5
Average Distance /cm	0.55

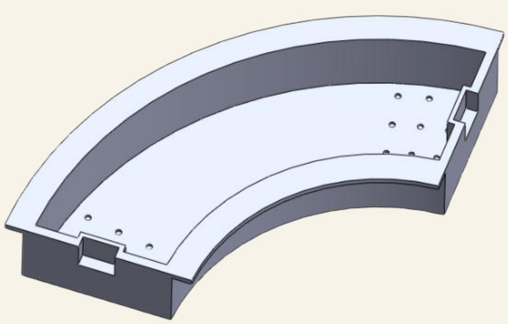
Experimental Data

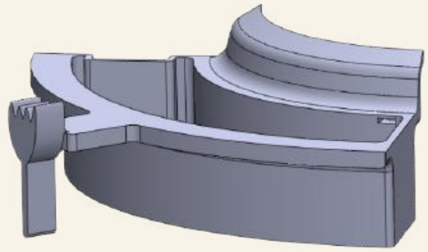
Water Dispenser UX

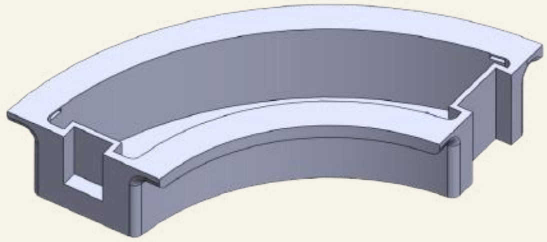
Pot Iterations

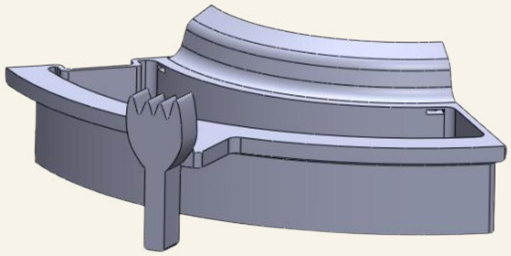
V1



V4

V2



V5

V3



V6

Experimental Data

Attractiveness

Experimental Procedures

Step 1: We contacted professors and asked them for approval to engage in product testing with their children

Step 2: We turned on the prototype and recorded the number of individuals who interacted physically with our prototype

Step 3: We kept track of the timing after the prototype was turned on, and stopped when there were no more other children in the area.

Experimental Results

Attractiveness

Time after prototype was switched on/min	Number of adolescents who approached and interacted with prototype
2	1
4	0
6	2
8	2
10	1

Experimental results show that our prototype is aesthetically pleasing and attractive

Experimental Data

Retention

Experimental Procedures

Step 1: We contacted professors and asked them for approval to engage in product testing with their children

Step 2: We turned on the prototype and allowed interested users to interact and explore our product

Step 3: We recorded the longest duration of continuous usage by the interested users.

Experimental Results

Retention

User	Duration of longest continuous interaction/ min
1	20
2	36
3	30
4	28
5	40
6	15

Experimental results show that our prototype is able to capture and retain the attention of interested users.

Budget

Prototype 1	Cost
Mechanical Components	$ 300
Electrical Components	$ 400
Tools & Consumables	$ 200
TOTAL AMOUNT	**$ 900**

Prototype 2	Cost
Mechanical Components	$ 100
Tools & Consumables	$ 100
TOTAL AMOUNT	**$ 400**

Prototype 3	Cost
Consumables	$ 100
TOTAL AMOUNT	**$ 100**

Consumables for prototype comprises mainly aesthetic components -primers, paint and lacquer

Budget Left: $150

Schedule

What was done from Week 8 - Week 13

Final CAD amendments

Product assembly

Aesthetic design and touch ups

GUI Design

GUI Integration

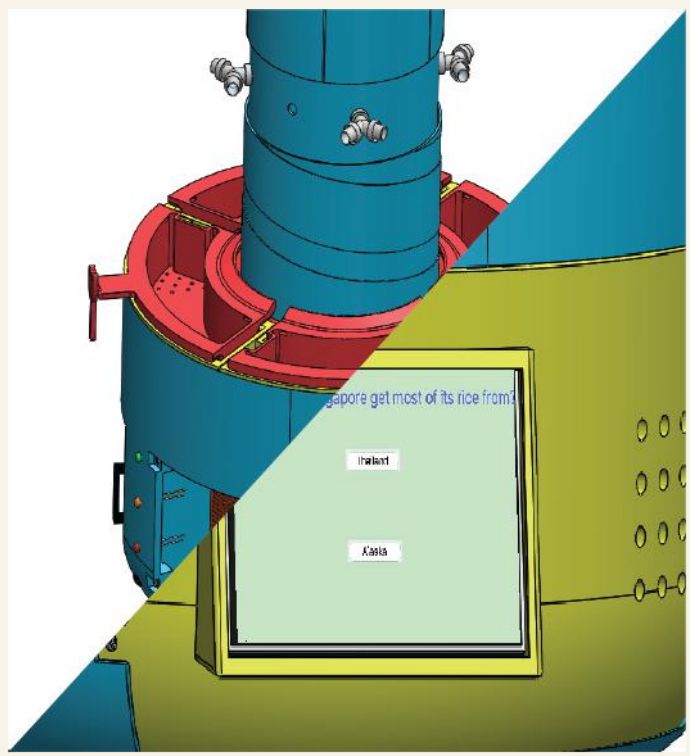
Product testing

What's Left:
Product Showcase

Summary

Impact/Innovation:

An EDUCATIONAL toolkit that will be deployed in collaboration with schools for students to experience the cultivation of microgreens in a FUN, EASY and ACCESSIBLE manner



Future Developments (1)

1

Integrated Motherboard

This will further compact the circuitry, freeing up valuable space to extend the functions of the prototype

2

Increased Size

This will extend the usability of the prototype as multiple users can interact with the prototype. This was surfaced by Professor Tee Hui

Future Developments (2)

3

Integration with Cloud Server

This enhances the GUI experience with the possible addition of a common leaderboard to promote friendly competition

4

Integration with an app

This will further improve the usability of the prototype as users can remotely track and control it