



ENDLESS GARDEN

Daniel Cabestrero, Amanda Curran, Victor Diaz
Gessner, Erika Kraft, Charlene Lam, Taylor Olender

Advisor: Professor Andrew Gouldstone

Endless Garden | Motivation

- More than 23.5 million Americans are affected by **Food Deserts** [1]
- **Food Desert:**
 - “Urban area with 10 or fewer (grocery) stores and no stores with more than 20 employees” [2]
- Limited access to nutritious food leads to the consumption of "empty calorie foods" [2]
- Only 25% of Americans garden[4][5]
 - Lack of Time
 - Lack of Space
 - Lack of Knowledge
 - Convenience of pre-grown food



[1]J. E. Wells and J. E. Gradwell, "Gender and resource management: Community gardening in Upstate New York," Agriculture and Human Values, vol.23, no.2, pp. 143–156, 2006.[Online].Available:<https://link.springer.com/article/10.1007/s10460-006-9002-8>. [Accessed: Jul. 15, 2025]

[2]E. Wells and J. E. Gradwell, "Gender and resource management: Community gardening in Upstate New York," Agriculture and Human Values, vol. 23, no. 2, pp. 143–156, 2006. [Online]. Available: <https://doi.org/10.1007/s10460-006-9002-8>. [Accessed: Jul. 15, 2025].

[4]R. Ryan, "Gardening Statistics & Trends (Data, Facts and Figures)," Raleigh Realty, May 28, 2024. [Online]. Available: <https://raleighrealty.com/blog/gardening-statistics-trends>. [Accessed: Jul. 15, 2025].

[5] Social Policy Lab, "Grow your blog community," Social Policy Lab, Apr. 23, 2021. [Online]. Available: <https://www.socialpolicylab.org/post/grow-your-blog-community>. [Accessed: Jul. 15, 2025].

Endless Garden | Market Research

Tabletop Modules



AeroGarden | Harvest Elite



Click & Grow | Smart Garden 3

Large Scale Systems



Lettuce Grow | Farmstand



Gardyn | Home Kit 4.0

Endless Garden | Hydroponic Terminology

Deep Water Culture (DWC)

A growing method where plant roots are suspended directly in a constantly oxygenated nutrient solution.

Substrate

A soil replacement that supports a plant's roots, retains moisture, allows air and nutrients in

Plug/Pod

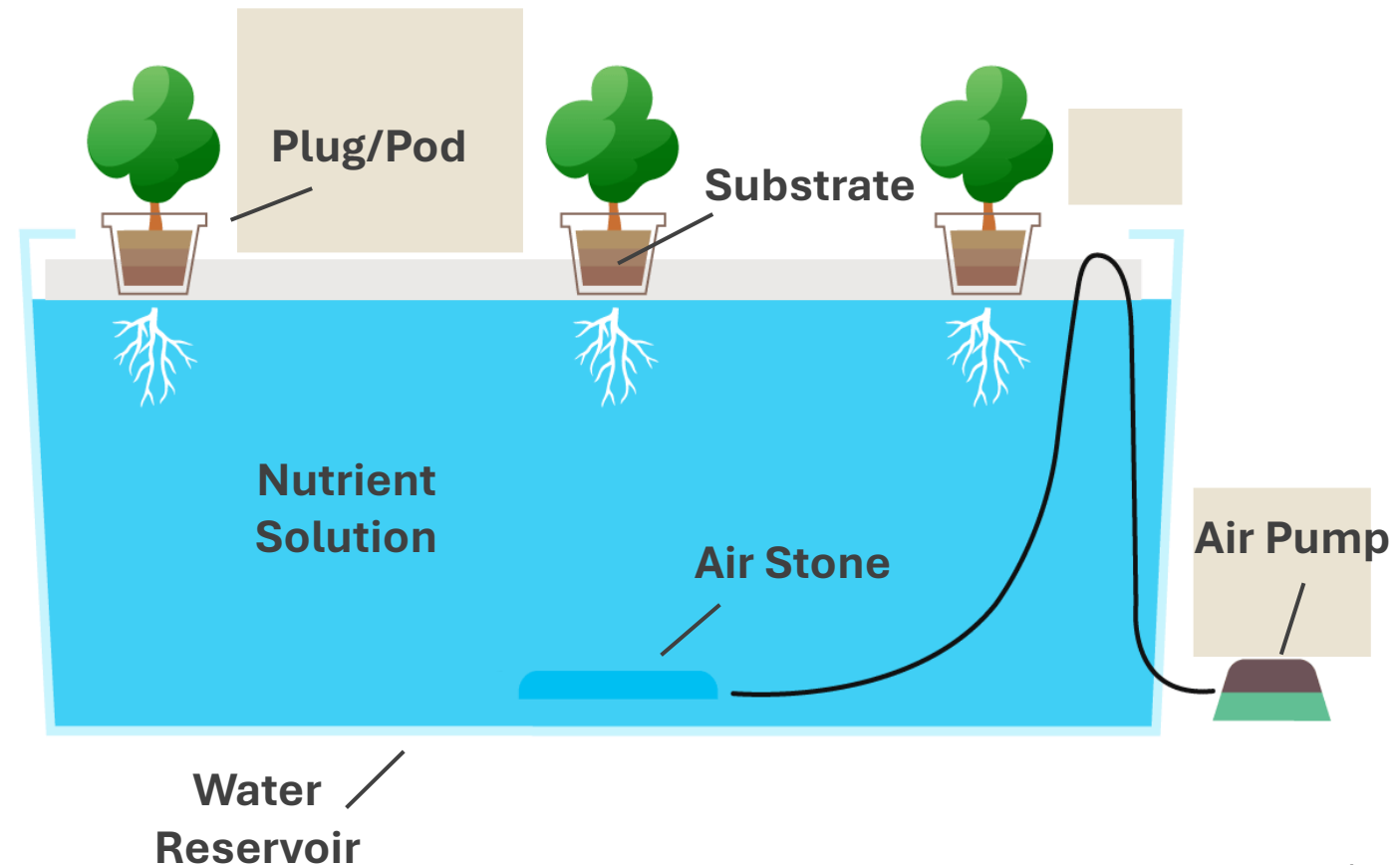
Provides support to the plant and substrate while allowing the roots to grow freely

Nutrient Solution

Delivers all essential minerals and elements to the plant – acts as the plant's food source

Air Pump and Air Stone

Work together to oxygenate the water and keep the nutrient solution moving



Endless Garden | Market Gap

Most indoor gardening systems rely on **batch growth** — everything grows at once, then stops. This means:

- **Inconsistent access to produce** (weeks with nothing, weeks with too much)
- **High maintenance requirements and complex setups** that assume users have time, interest, and gardening experience

There is *no existing indoor garden* designed for:

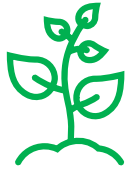
- **Busy people** who want fresh vegetables but can't maintain a finicky system
- **Food desert residents** who have limited or no access to fresh produce
- **Anyone who wants organic, pesticide-free greens without constant upkeep**

These groups don't need a hobby—they need **reliable, effortless access to fresh food**

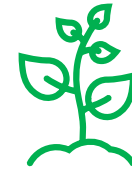
This is where the *Endless Garden* comes in!

- ✓ **Fully automated growth** (no light adjustments, no daily care)
- ✓ **Continuous harvesting**, one fresh head of lettuce every week
- ✓ **Grow organic, pesticide-free produce**, zero effort needed

We want to design for **real-life schedules and real-life food needs**



Problem Statement



To design an automated and continuous indoor gardening system to allow widespread access to freshly grown vegetables.

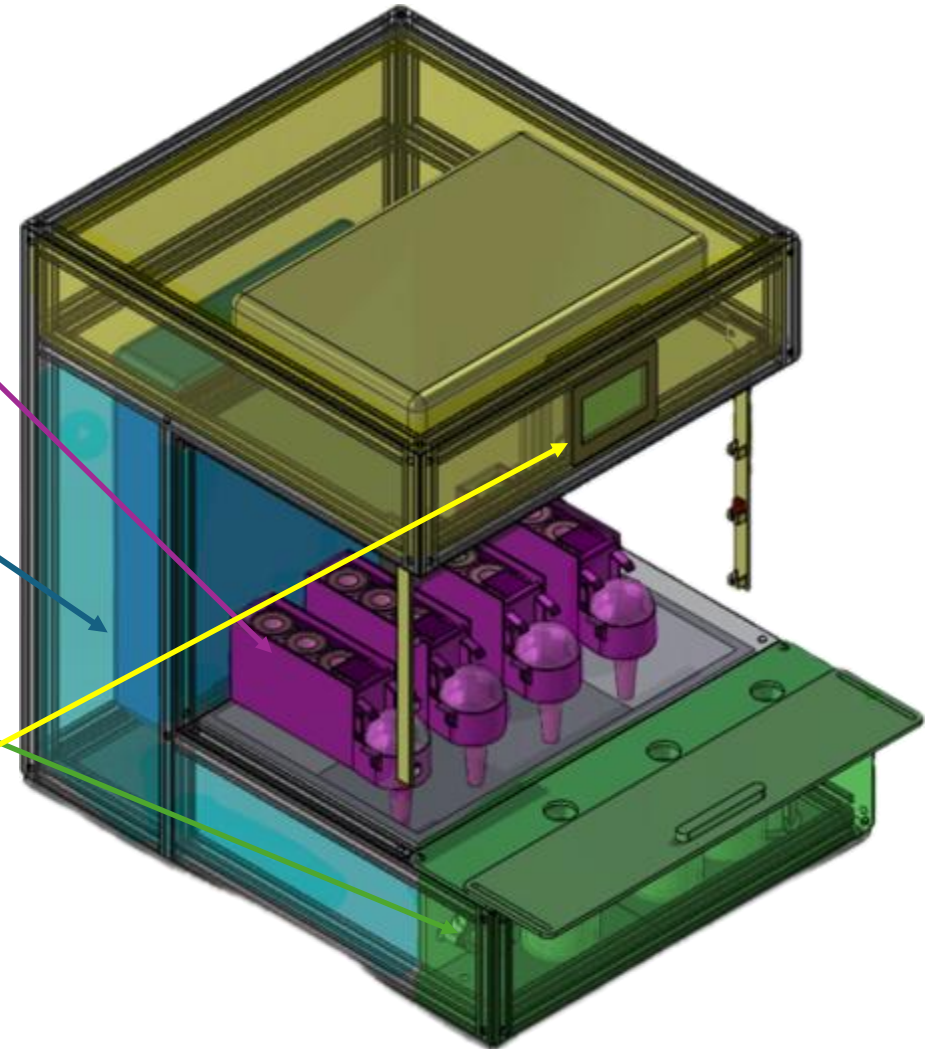
Endless Garden

1. Fill up the plug refill with pods

2. Fill up the water tanks

3. Fill up the Nutrient and pH Balance

4. Hit setup function on LED display



Endless Garden | Metrics

Challenge

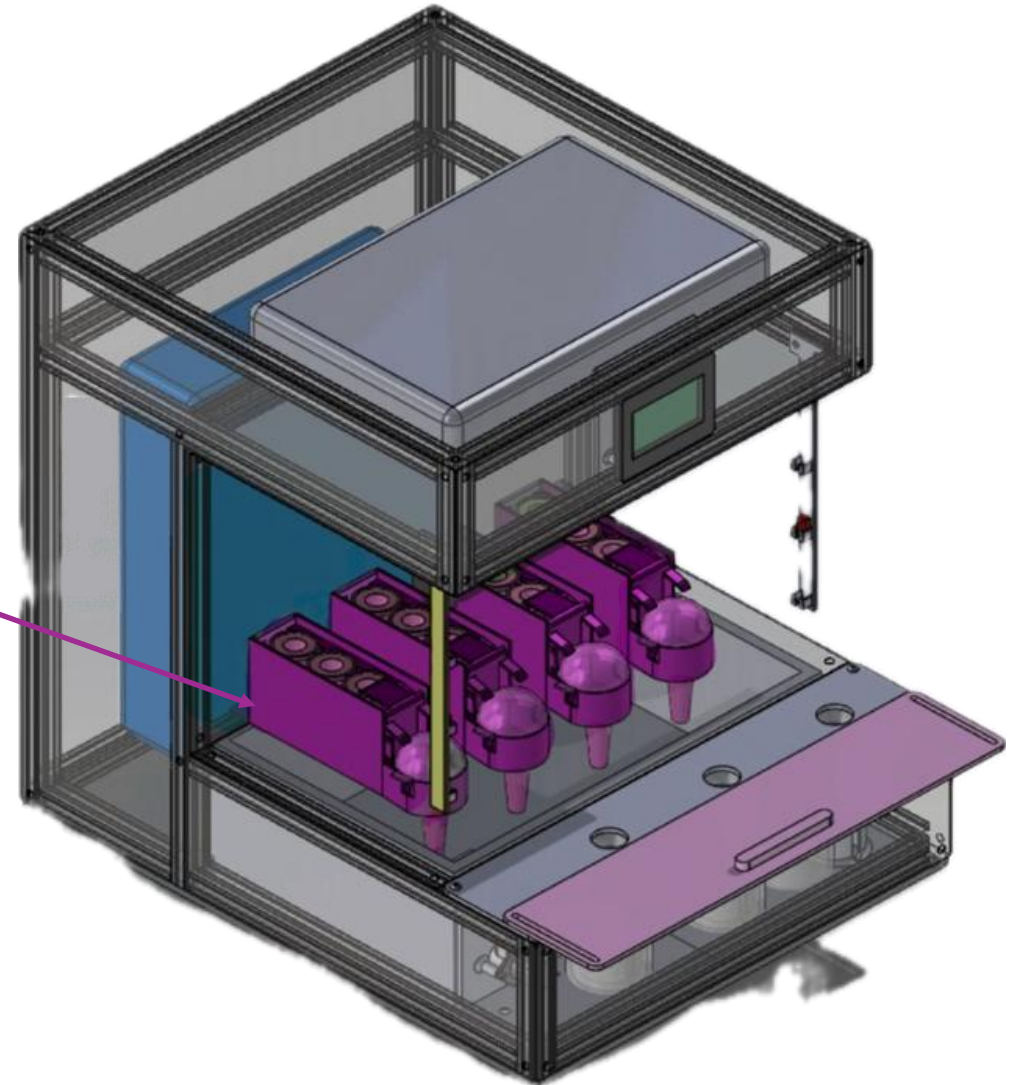
It takes about **one month** for Little Gem Lettuce to grow from a seedling to full maturity. This meant we could not test our product through a complete growth cycle.

Solution

During the beginning stages of the project, we changed our **metric of success** from “get plants to grow” to “*create an environment where Little Gem Lettuce will grow and thrive*”.



Plug Refill



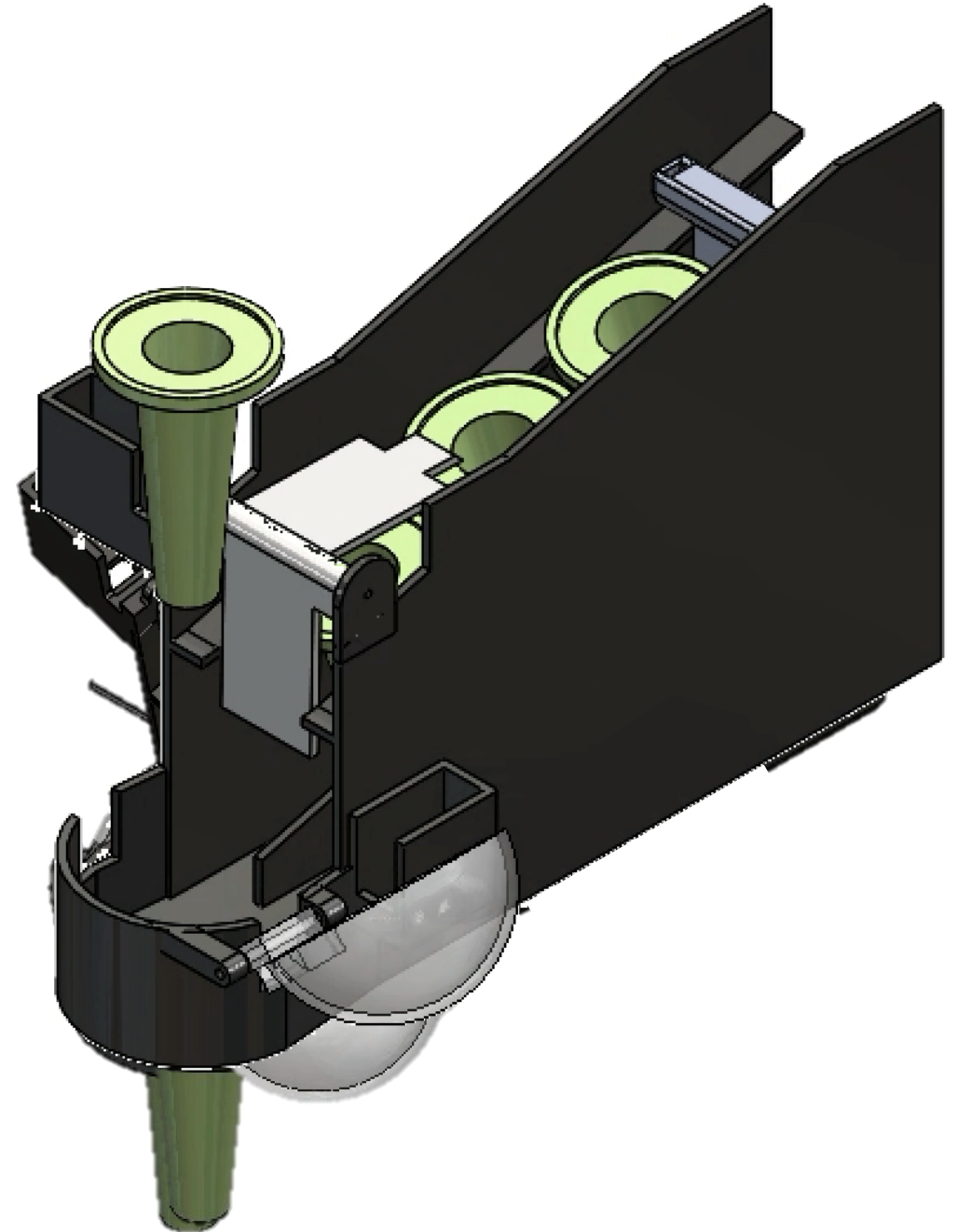
Plug Refill | Overview

IR Sensor: Detect if there is a pod in place

If there is no pod in place a **door** will open

Then a **germination lid** will close for 14 days

Hall-Effect: Detect when pods need to be **refilled**



Plug Refill | Technical Challenges

Major challenge: The **lightweight** nature of the pods

Challenge:

1. Various springs were too strong for the system, pushing the pods with **too much force**.
2. Original sensor, a **micro switch**, needed more force to be activated than the pods could provide.

Solution:

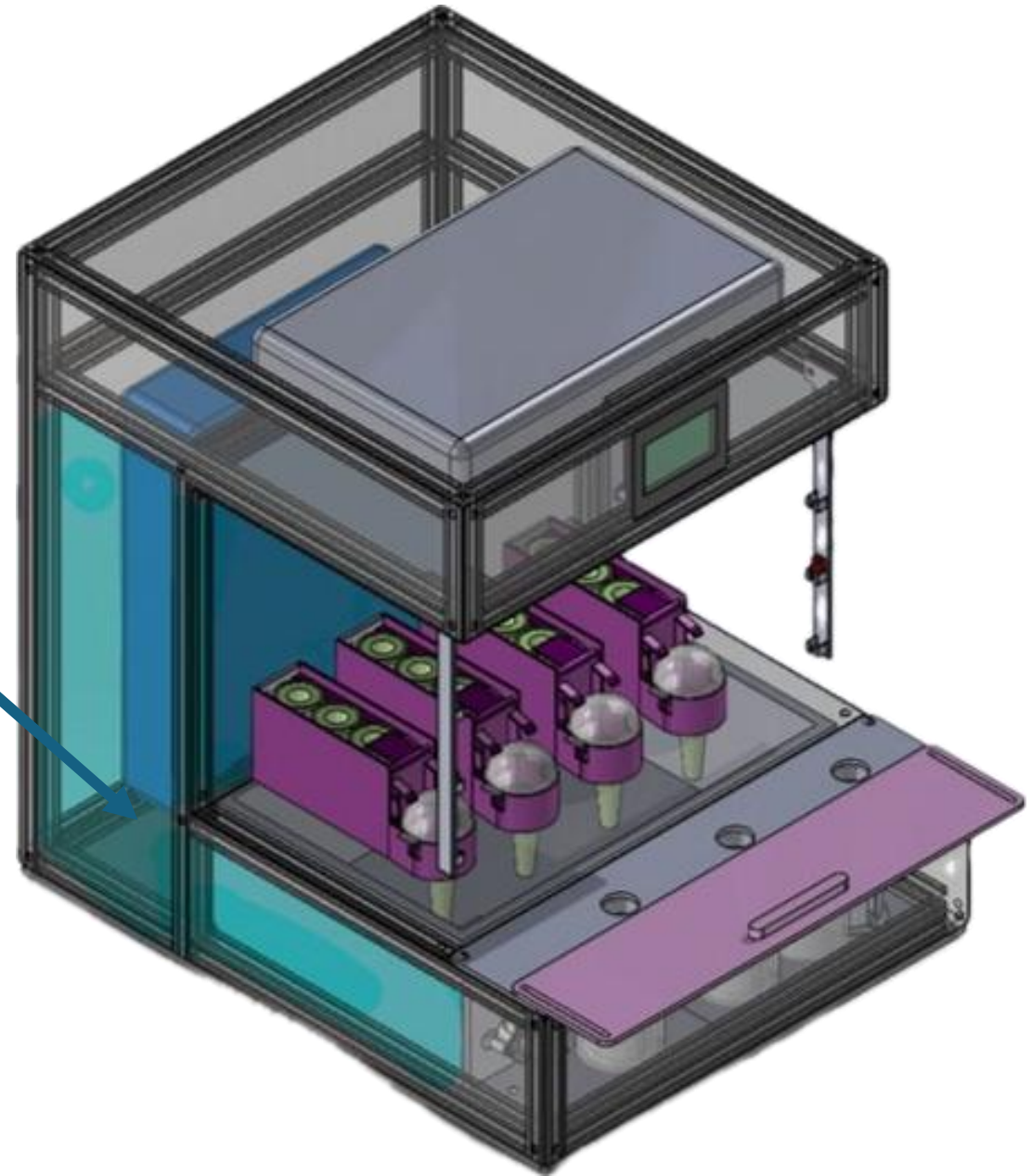
1. Our **gravity fed design**: allowed the pods to fall into place without pushing the system with too much force.
2. A **reflective IR sensor**: simply detected the pods under the systems conditions and did not require any changes to the pods.



Weight

Plant full grown: 0.42 lbs
 Pod: 0.01 lbs
 Pod/Substrate: 0.04 lbs

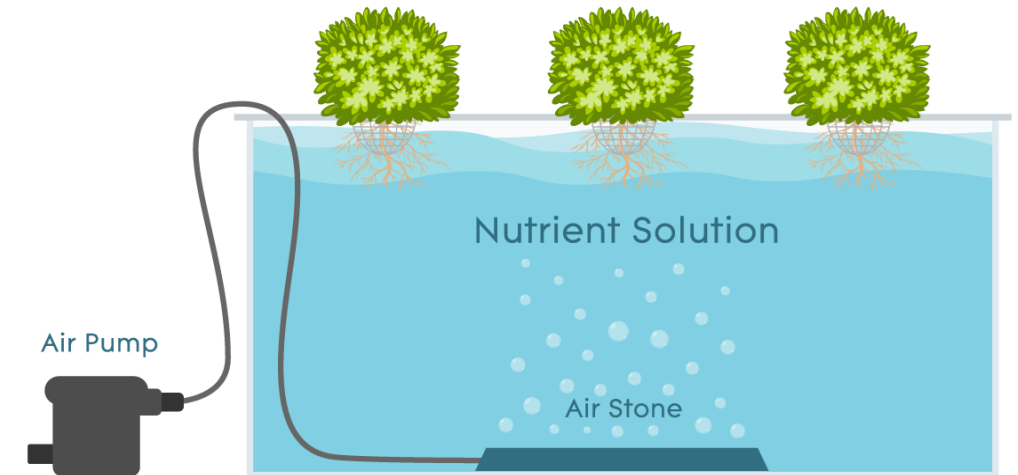
Water System



Water System | Overview

The water subsystem provides **automated, reliable water delivery** via a gravity-fed system

- Two water-level sensors monitor both reservoirs (bottom + backup)
- A **solenoid valve** opens/closes
 - This is based on bottom-reservoir water-level readings. A **flow sensor** measures real-time flowrate to verify successful refill events
- Two **peristaltic pumps** run continuously for aeration and circulation



Water System| Technical Challenges

Challenge:

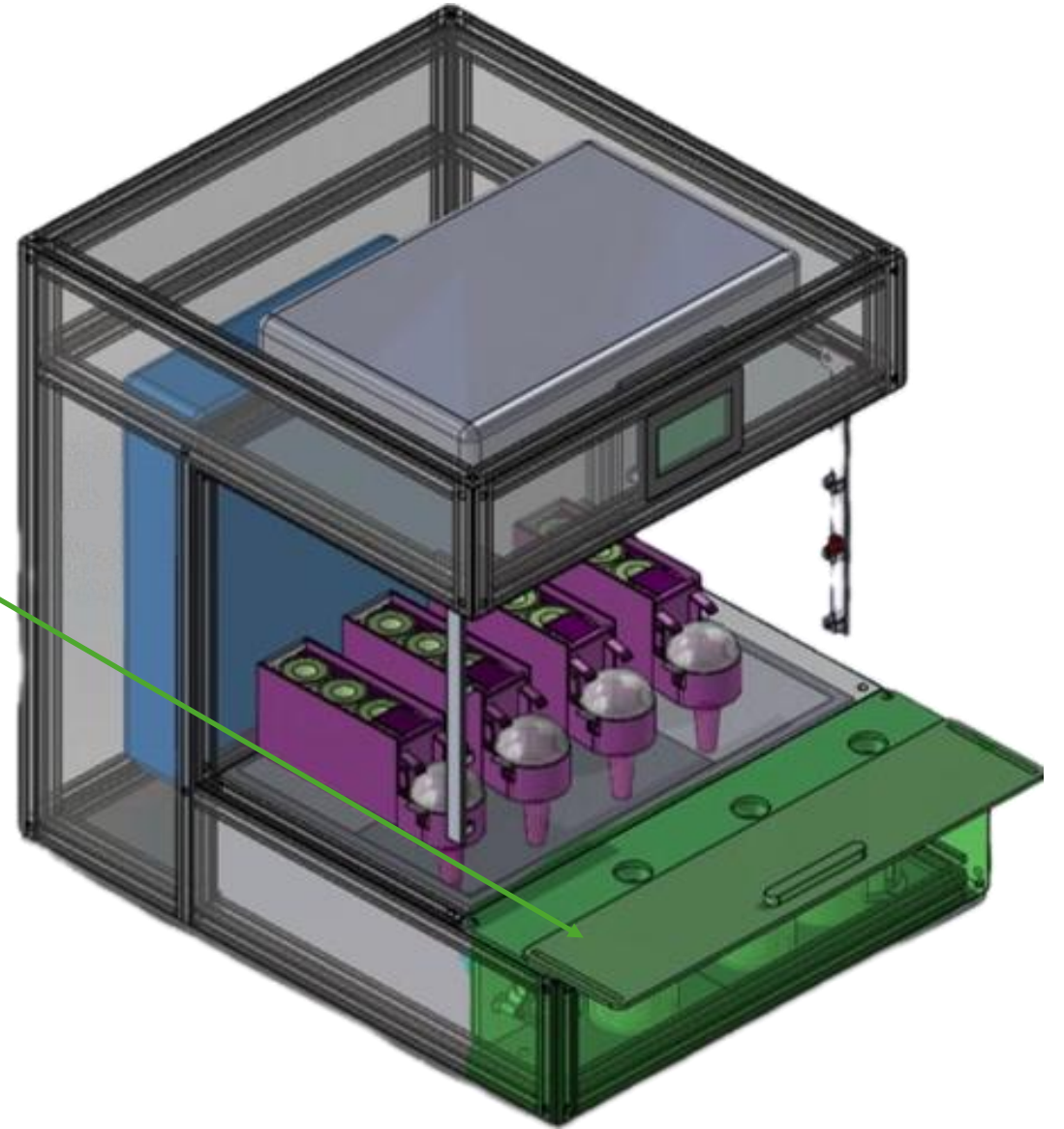
1. Ensuring **reliable**, leak-free water flow
2. Ensuring **reliable** gravity feed design

Solution:

1. Used standardized tubing and hose clamps
2. Rerouted tubing so the entire line maintains a **downward** grade, preventing air pockets or back-pressure.



Nutrient Controls



Nutrient Controls | User Set Up

1. Fill **nutrient container**

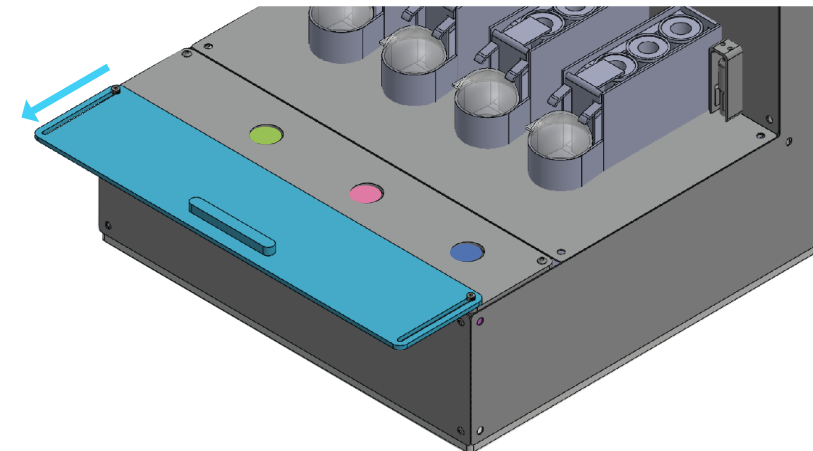
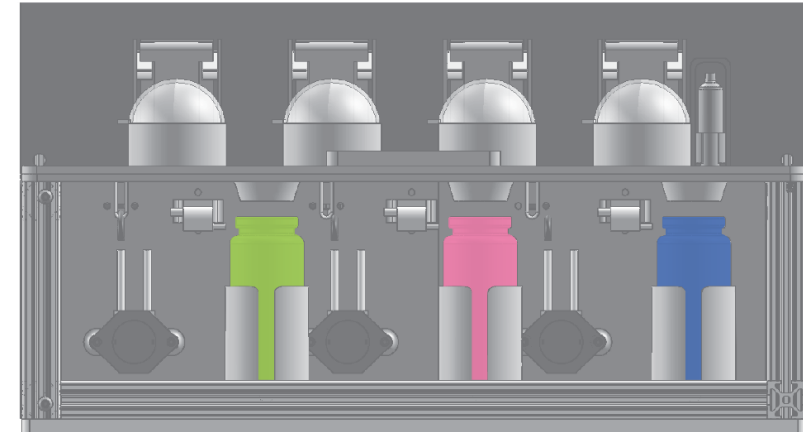
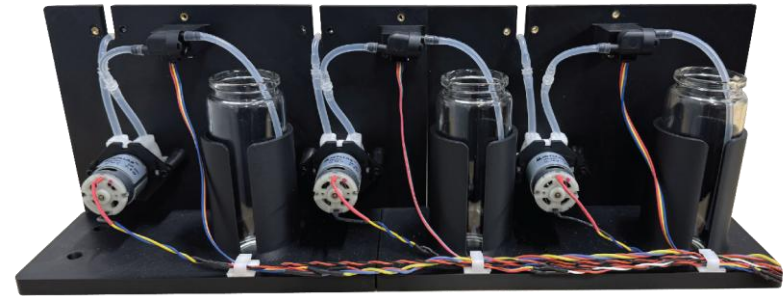
Hydroponic nutrients replace those normally absorbed from soil

2. Fill **pH up container**

pH adjustors that raises pH when tap water and nutrients are too acidic

3. Fill **pH down container**

pH adjustors that lowers pH when tap water and nutrients are too basic



Nutrient Controls | Internal Components & Logic

pH sensor

Measures pH in main water tank

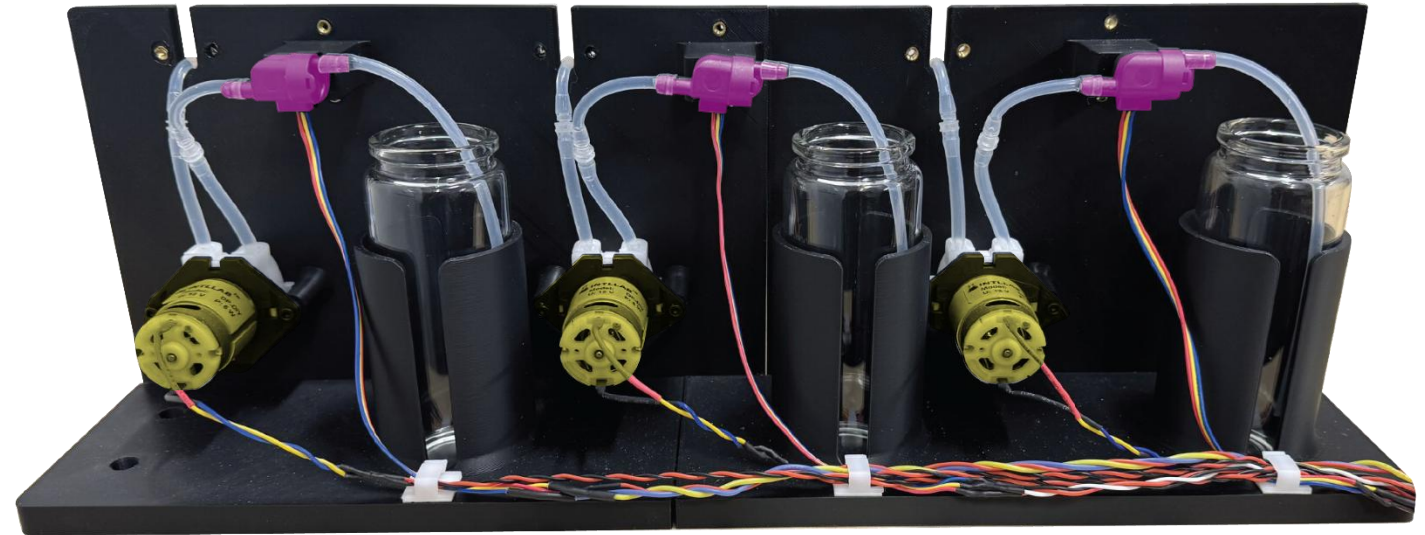


Flow sensors

Flow sensor enables precise dosing and detects empty jars

Peristaltic pumps

Nutrients dosed at 10 mL per 4 L water pH maintained at 5.8-6.2 for optimal growth



- Bang-bang controller utilizing for dosing pH adjustors based on pH sensor feedback
- Pumps achieved <1% error from optimal nutrient ensuring precise volumetric delivery across all pump channels

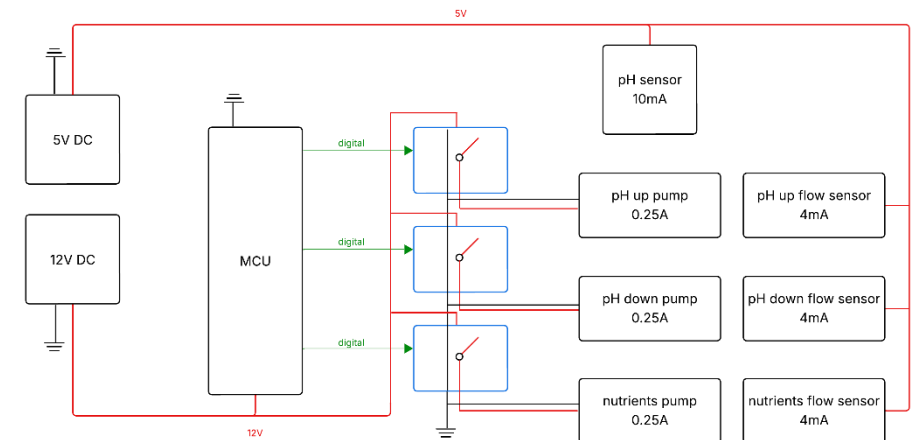
Nutrient Controls | Integration

Phase 1: individual component testing

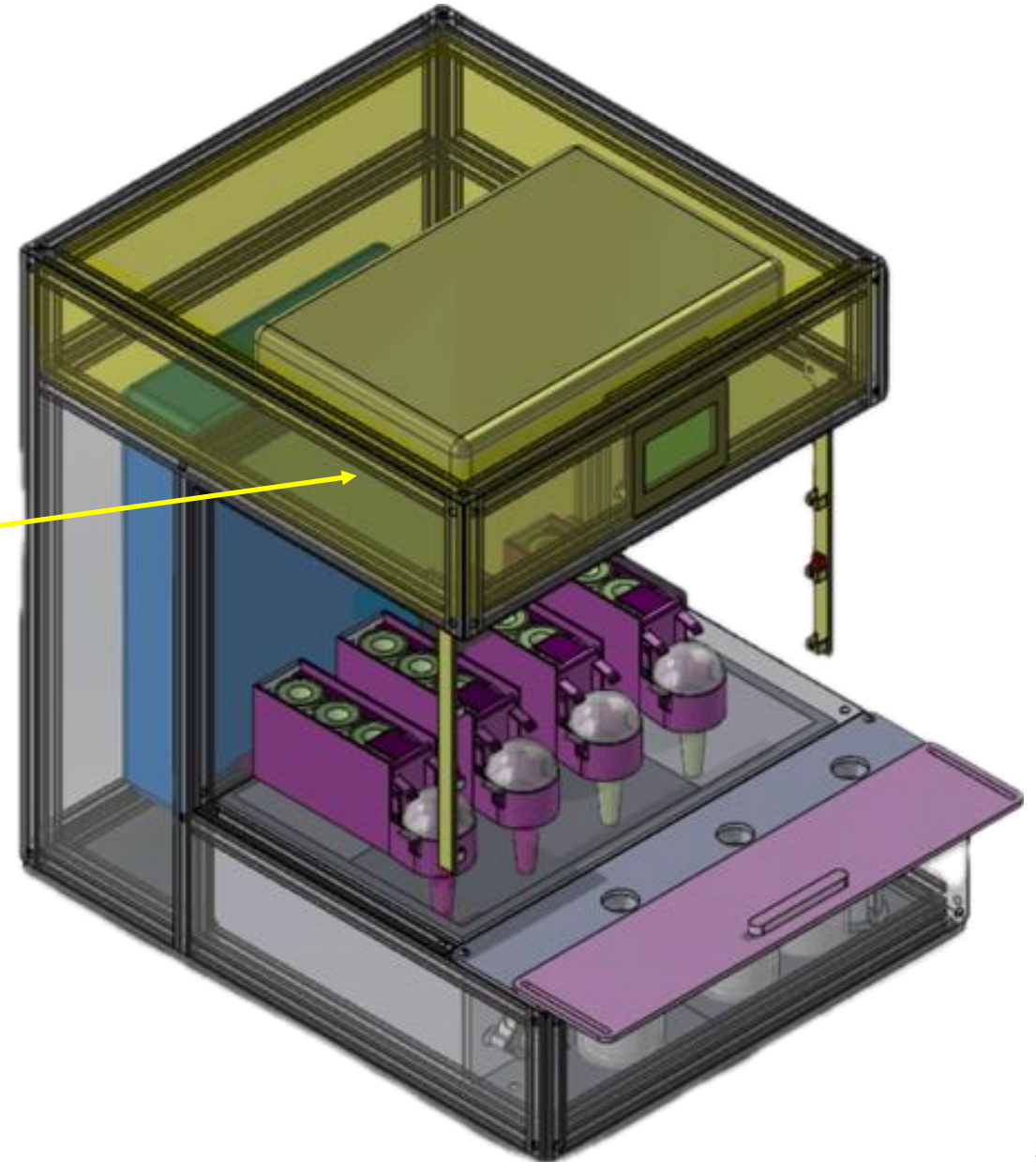
Phase 2: pH integration

Phase 3: nutrient integration

Phase 4: full integration



User Interface and
Experience



UI & UX | Overview

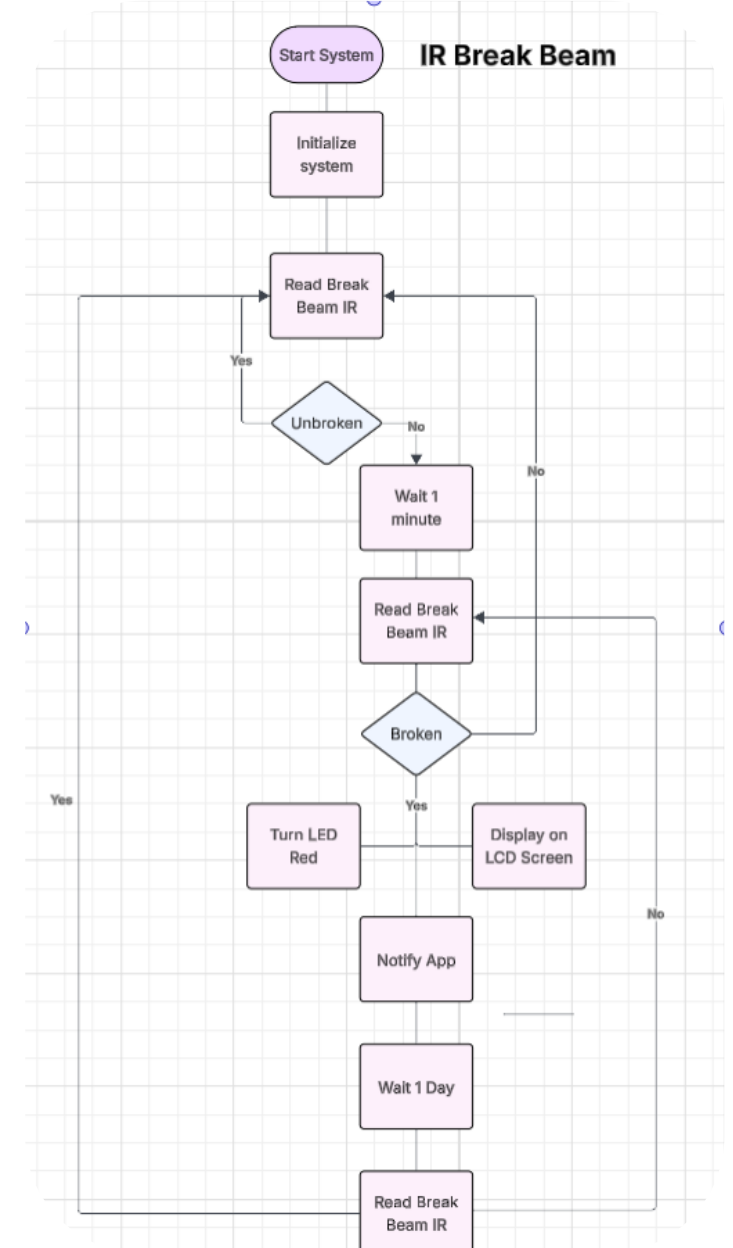
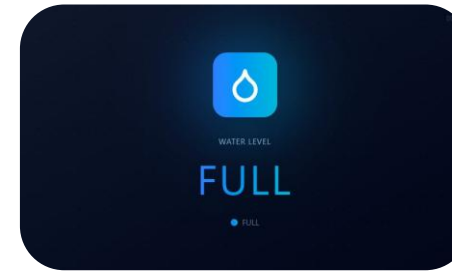
User interacts and gets feedback with the appliance in 3 main sections

3.95in LCD panel gives

- Water Level
- Harvest Readiness
- Nutrient Level
- Clock
- pH Level

2 LED full spectrum grow lights each producing 900 lumens with a 12-hour timer decreasing user interaction

Break Beam IR sensor informing when plant is ready to be harvested displayed on LCD



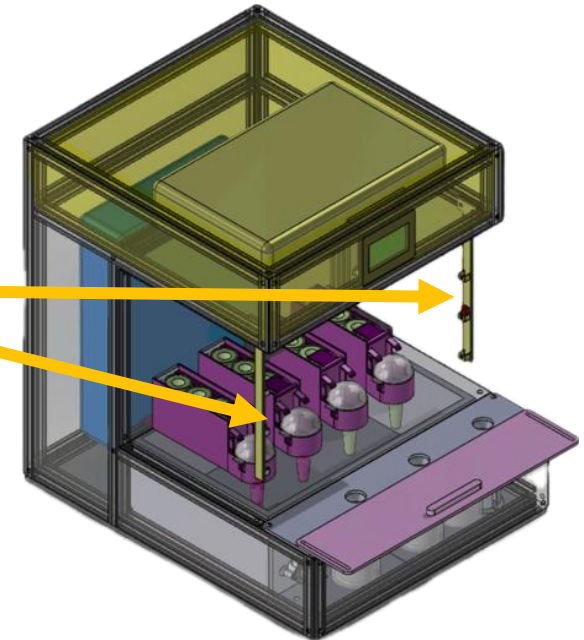
UI & UX | Technical Challenges

Challenge:

1. Original 4in TFT SPI display was causing a lot of problems by only giving a **white screen** apart from once
2. **IR Sensor Placement** for modularity and positioning for plant growth

Solution:

1. **Last minute change** of displays from 3rd party device to 1st party compatible screen
2. Designing multiple **mirrored slots** for IR break beam sensor



Endless Garden | Consumer Maintenance Cost

Electricity

- **Grow Lights:**
 - 85.44 kWh / year
 - \$14.92 a year
- **Pumps:**
 - 57.8 KWh / year
 - \$10.10 a year

Consumables

- **Total Water :**
 - 356L / year
 - \$1.50 / year
- **Pods:**
 - 52 pods a year
 - \$26.5 per year

Operating Cost of Endless Garden: **\$53.02 per year**
Comparable Cost of Produce at Whole Foods: **\$119.08 per year**

Endless Garden | Key Successes

Each subsystem produces **reliable and repeatable** conditions for Little Gem

1

2-week plant germination period

2

Grow lights provide required lux at each plant stage

3

Full water turnover every **2-2.5 hours**

4

Nutrient and pH level **confirmed**

Endless Garden | Impact and Future Work

Impact: Furthering technology in automated indoor gardening

Future Works

- Potential second capstone project
- Opportunity to growing different plants not just Little Gem
- Creation of an app for convenience
- Optimization of weight and size

