The Bloom Box Project

Team Designation

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Executive Summary

The goal of this lab task is to create and assess a system, for growing plants that caters to the needs of city dwellers who have limited space. The objective is to design a flexible plant shelf with automated watering and lighting features providing an option for individuals interested in gardening. This project focuses on applying principles related to plant growth, environmental management, and user engagement to develop a user-friendly gardening solution. The importance of this initiative lies in its ability to promote living, increase access to produce, and enhance the well-being of city residents. With urbanization on the rise and a growing interest in self-sustainability, the creation of a plant-growing system presents a solution to these challenges and contributes towards building healthier and more resilient communities.

The equipment used for growing plants indoors provided interesting results and patterns that show how effective it is at enabling indoor gardening. Urban people with limited room can maintain multiple plants simultaneously inside their limited living areas thanks to the plant shelf's design, which maximizes space efficiency. Also, the experiment's plants remained healthy and strong throughout, demonstrating the effectiveness of automated lighting and watering systems in sustaining ideal development situations. The relationship between UV light exposure and faster plant growth in particular showed the value of using the right lighting technology in indoor gardening setups and the potential for higher productivity.

It is important to recognize probable errors and restrictions, though. Future research may need to use controlled surroundings to ensure stable circumstances, as changes in outside variables like temperature and humidity may have affected the results of the growth of plants. Also, differences in growth rates may be caused by the variety of plant species and individual traits, resulting in the need for more research into the best plant choices for indoor making. The experiment's findings provide useful data on the effectiveness of the indoor plant growing system, even with these potential disadvantages. This opens up opportunities for further study and development to enhance indoor gardening methods and advance sustainable living choices.

The experiment concludes that the indoor plant growing system, with its automated features and design that maximizes space use and maintains ideal growth conditions, is an effective tool for urban indoor gardening. Plant growth rates and UV light exposure have a positive relationship, which shows how important it is to use the right lighting technology to increase production. To optimize the system's advantages going forward, improving automated features and finding the best plant species for indoor growth is a good way to go about it. The system's potential to promote sustainable living as well as improve nutrition can be further benefited by encouraging indoor gardening activities, especially among urban people. This illustrates the system's significance for current agricultural solutions.

Problem Definition Review

1. Introduction

The research of the team is angled towards a user demographic compromised of parents who want to cultivate a wholesome lifestyle for their families and children while perpetuating their budgetary considerations. Likewise, our target audience reaches past solely parents to all those who wish to embrace a cost-friendly, healthy lifestyle. The team concedes that there are financial limitations that come with keeping a healthy diet, and we have chosen to rise against this challenge, to provide an alternative for anyone looking to live a healthy and wholesome lifestyle. The team's proposed solution would involve the creation of a household device that our users could implement into their homes that would enable a safe and simple cultivation of fruits and vegetables that are commonly found within a healthy diet. Consequently, this would lessen the burden of buying healthier food options that tend to sway more on the expensive side of groceries, and subsequently remove the need for a user to travel out of their way to purchase groceries at a specialized healthy foods store. As an added benefit, this would be…

- Aesthetic and low maintenance.

2. Problem Definition

a. User Persona and Pains and Tasks

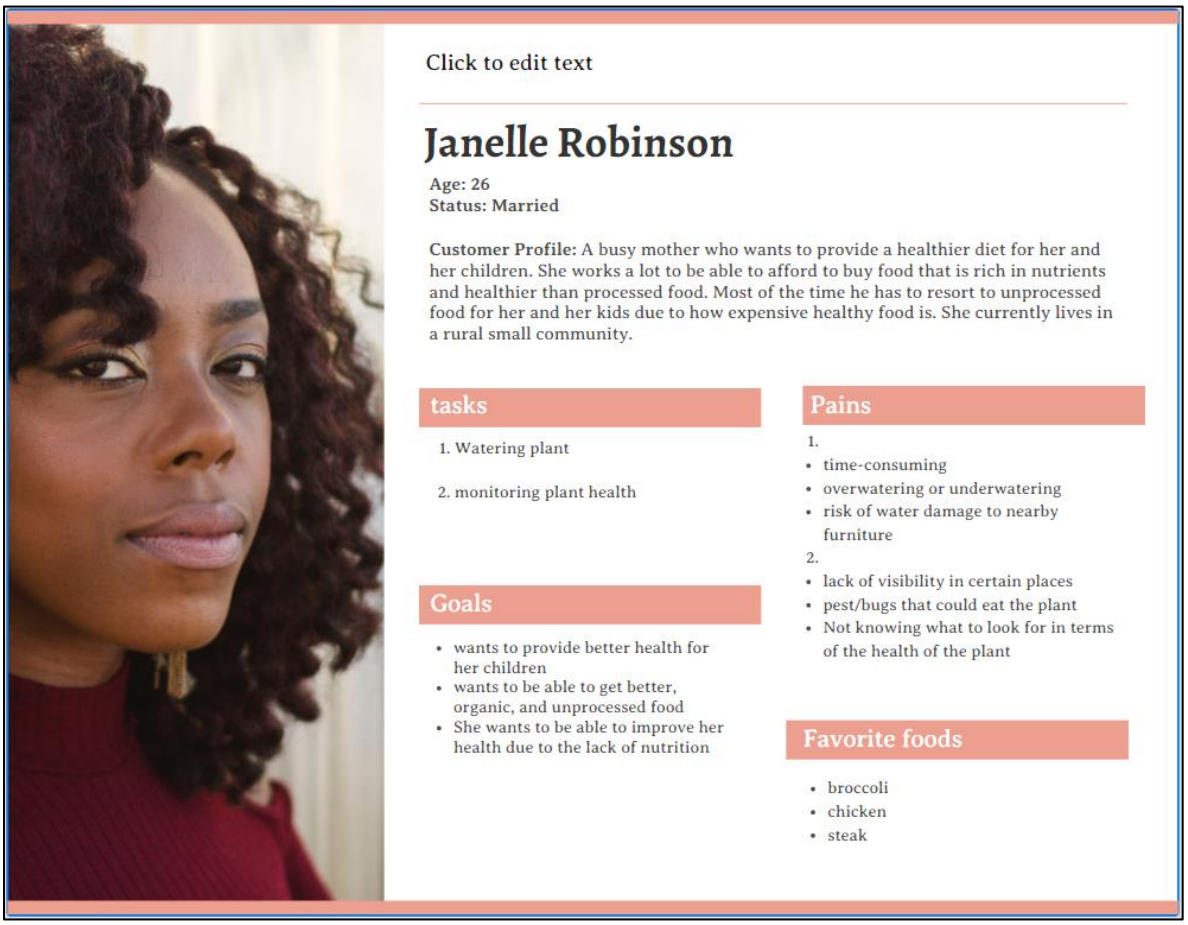

Figure 1. User Persona

The user group was selected from an interview done with a person that has trouble getting healthier food for their family.

3. Research Plan

Table 1. Research Data

Research Question	Qualitative Data Collection	Quantitative Data Collection
How does food affect overall health? What side effects are shown?	Interview with a person from the user group (See Appendix B).	Data about the effects of diet on mental well-being [1].
What foods provide great nutrition? What pains are associated with getting this food?	Article about the advertisement of healthy food and drinks. [2] Article about how people interpret healthy eating [3].	Data about the importance of high quality foods [4].
What is the amount of unhealthy food consuming every day? Who is responsible for making this food?	Article about potential reasons and solutions for unhealthy food consumption [5]. Article about the potential culprit of junk and unhealthy foods [6].	Data about the junk food intake among US adults [7].
How does household income affect the affordability of healthy foods?	Article about how low-income parents evaluate the cost of food [8].	Data about the quality of food purchases by household income [9].
How does location affect the quality of food?		Data about the healthy dietary patterns of US households [10].

The team's research topics analyzed the connections between food, nutrition, health outcomes, and socioeconomic factors. To educate the public against diet-related health issues, it is important to look into the side effects of food choices and understand how they affect general health. Examining the accessibility, availability, and difficulties in getting nutritious foods gives information on how to promote nutritional habits that are healthier and address gaps in food accessibility. To reduce the negative effects of bad eating habits, specific measures have been guided by a review of the factors that contribute to unhealthy food consumption and the effects that this has on society. Furthermore, examining how household income and geography affect food affordability and quality shows the socioeconomic factors that determine food availability and shows the need for fair food policies and interventions.

4. Research Results

- Based on the research and discussions, the team had decided to focus on the task of growing plants.

a. Creating User Value

i. Gains

- The plant shelf offers an educational experience in plant growing and gardening.
- The plant shelf provides users with the flexibility to grow whatever they want and the knowledge of what goes on inside it.
- The plant shelf enhances the aesthetics and appeal of the users' home.

ii. User Needs

1. **Low maintenance -** Having low maintenance allows the users to grow their plants effortlessly and without any hassle.
2. **Reliability -** Having good reliability ensures the users' plants will be healthy and thrive.
3. **Customizability -** Having customizability allows the users to grow whatever plant they want and whenever they want.
4. **Automatic monitoring -** Having automatic monitoring allows the plant shelf to automatically make adjustments that would be best for the users' plants.
5. **Alerts and notifications -** Having alerts and notifications will keep the users informed whenever there's an issue with the plants and tell them what the issue is.
6. **Aesthetics -** Having good aesthetics makes the plant shelf feel nice and enjoyable for the users to look at.

iii. Pairwise Comparison Chart

	Low maintenance	Reliability	Customizability	Automatic monitoring	Alerts and notifications	Aesthetics	Total	Normalized	Predicted
Low maintenance		1	1	1	1	1	5	**5.0**	5
Reliability	0		1	1	1	1	4	**4.0**	4
Customizability	0	0		1	1	1	3	**3.0**	3
Automatic monitoring	0	0	0		1	1	2	**2.0**	2
Alerts and notifications	0	0	0	0		1	1	**1.0**	1
Aesthetics	0	0	0	0	0		0	-	0

Figure 2. Pairwise Comparison Chart

After comparing the user needs with each other, the team found that having low maintenance is the most important user need, with a normalized score of 5.0, having reliability is the second most important user need, with a score of 4.0, having customizability is the next most important user need, with a score of 3.0, having automatic monitoring is the next important user need, with

a score of 2.0, having alerts and notifications is the second least important user need, with a score of 1.0, and having aesthetics is the least important user need, with no normalized score.

b. Market Character

iv. Stakeholders

- **Families/Households -** The families will be growing and eating their own food. This will have a positive impact because they will be getting healthier and unprocessed food.
- **Supermarkets –** The supermarkets are negatively affected because people will be growing their own produce, which causes the number of customers to decrease.
- **Food Providers -** Since the produce and food will be grown at home and will be of higher quality, food providers will be negatively affected because less people will be buying from them.

v. Market Size

The primary end user of the plant shelf will be people that live in urban areas and have limited outdoor space, but still have an interest in growing their own food. Research shows that interior design trends, urbanization, and the need for biological features in indoor environments are driving an increasing interest in indoor planting. Research also emphasizes the need to address gaps in the access and cost of healthy foods, especially among low-income people, to improve overall diet quality and lower the risk of diet-related illnesses [8]. In this setting, home gardening emerges as a useful and accessible way for people to add fresh produce to their diets, improve their health by interacting with nature, and enjoy gardening activities. Urban areas can also benefit from gardening as a way of encouraging better lifestyles and a stronger connection to nature, even in situations in which area is limited [11]. Due to developments in design and the need for natural elements indoors, home gardening is increasing in popularity in urban areas where outdoor space is limited. Through connections with nature, this approach not only allows urban residents to include fresh produce in their diets but also promotes better health and lifestyles [12].

vi. Current Alternatives

Table 2. Current Alternatives Competitive Matrix

User Need	AeroGarden	Click & Grow	Lettuce Grow	The Rise Garden	Hydroponics Growing System
Low maintenance					

Reliability	Reliable with some plants but not others.				
Customizability					Customizable aesthetically with machine color, but not plant options to grow
Automatic monitoring					
Alerts and notifications				Somewhat but app was inconsistent	
Aesthetics					

Green shaded box represents meeting the user need. Red shaded box represents not meeting the user need. Yellow shaded box represents somewhat meeting the user need.

Based on the results of the research, the team has found that many of the current indoor plant growing systems have low maintenance, good reliability, and automatic monitoring, but lack the customizability that some users may want. It also appears that the team had concluded that many users would prefer to have alerts and notifications for their system, as well as aesthetics, as the devices are a part of their homes.

5. Value Proposition

Introducing the team's innovative indoor plant growth technology, which combines sustainable wellness with urban life. Their strategy, which is based on a thorough study of indoor plant-keeping methods, appeals to the many requirements of people who want to add plants to their living areas. This system includes important information about the reasons people keep indoor plants, such as wanting to raise aesthetic appeal, improve mental health, and improve air quality [14]. Focusing on the importance of health, this plant-based system encourages people to have meaningful connections with indoor vegetations through hands on engagement. By offering a user-friendly solution, this system contributes greatly to sustainable lifestyles and creates healthier environments [15]. Join the team as they help to transform and improve people's homes and lives through the exciting addition of an indoor plant growing system with many benefits backed by plenty of research.

6. Design Focus

The team initially focused on the specific needs of parents who wanted to lead their families to wholesome and healthy lifestyles. While they acknowledge that healthy eating is oftentimes expensive, or unavailable for parents, they wanted to offer an alternative to alleviate this user pain. The team's design focus here required a deep understanding of the obstacles that their chosen demographic had to go through, such as the cost and availability of healthy and wholesome food and creating a product that eliminates those user pains. Additionally, they chose to expand the user group to include other individuals looking to grow plants rather than just

solely focusing on parents, so that our design can focus on growing plants inside, with low maintenance, and for less money.

Concept Development Review

1. Concept Brainstorming and Ideation

a. Process Description

The team's brainstorming sessions included making basic sketches of the product. writing down their key ideas on the whiteboard, taking the best ideas into consideration. They also researched and investigated similar products that were already made and tried to improve on those products. The team took user needs such as reliability, low maintenance, and customizability into account when drafting their first concept sketches. The team's sketches showed durability in the enclosures along with flexibility and customizability and allows users to make changes based on their preferences.

b. Brainstorming Results

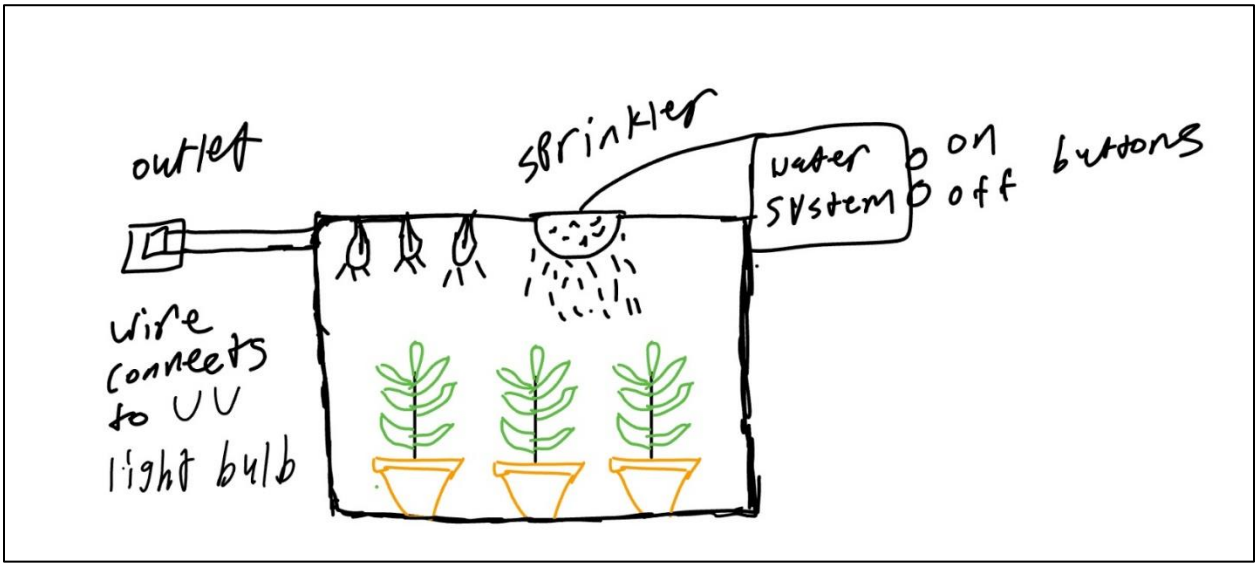

Figure 3. Concept Sketch 1

The team's first sketch addressed user needs by its reliability and convenience. The sketch includes a switch that turns the water on and off, which connects to a water sprinkler into the enclosure. There are also UV light bulbs inside the enclosure that connect to an outlet which can be turned off and on with a switch.

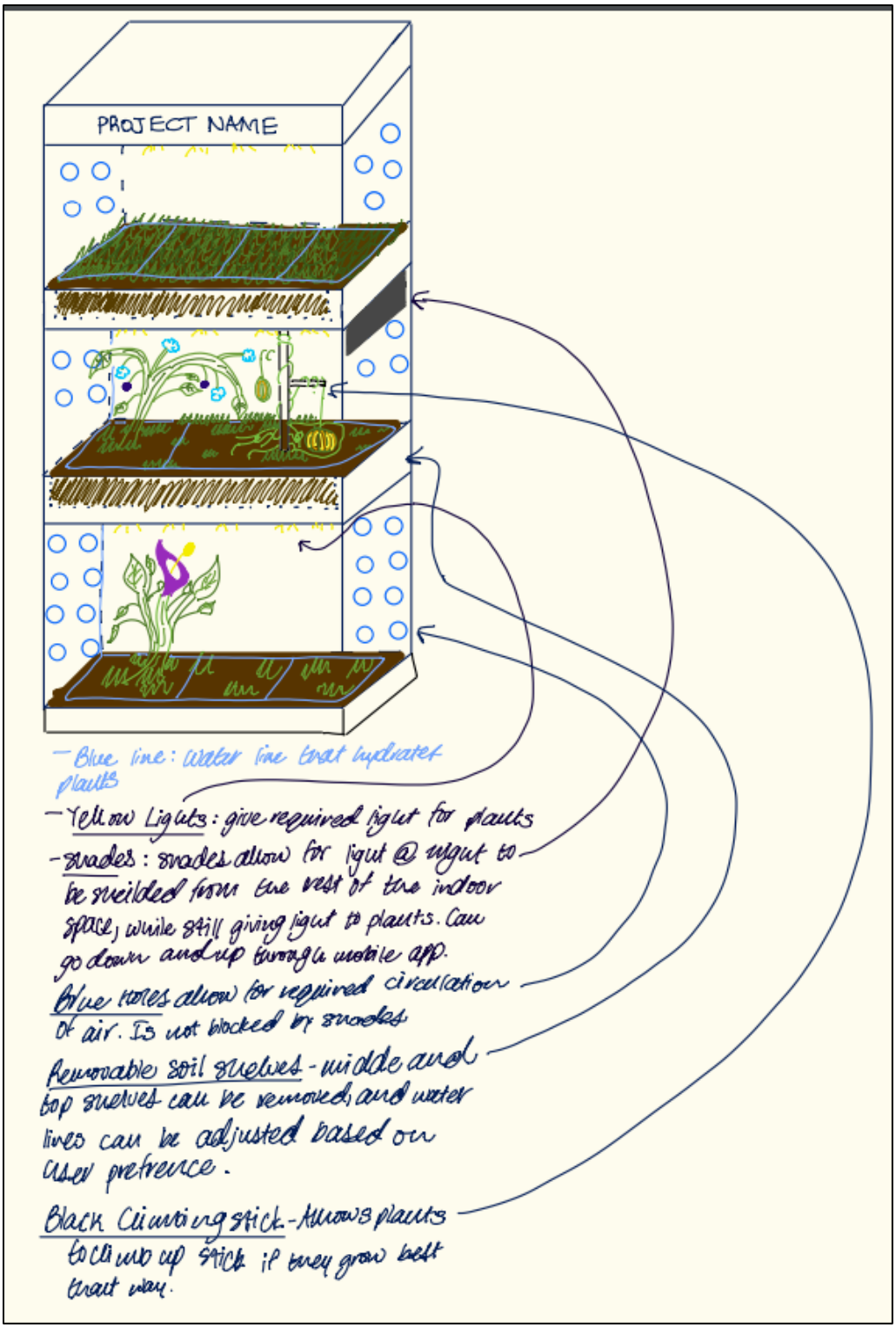

Figure 4. Concept Sketch 2

The team's second sketch reflects customizability and proper simulation of plant environment. The sketches include lights, blinds, and water lines that can be controlled by the user on a switch through a mobile app, as well as removable shelves for different size plants to grow.

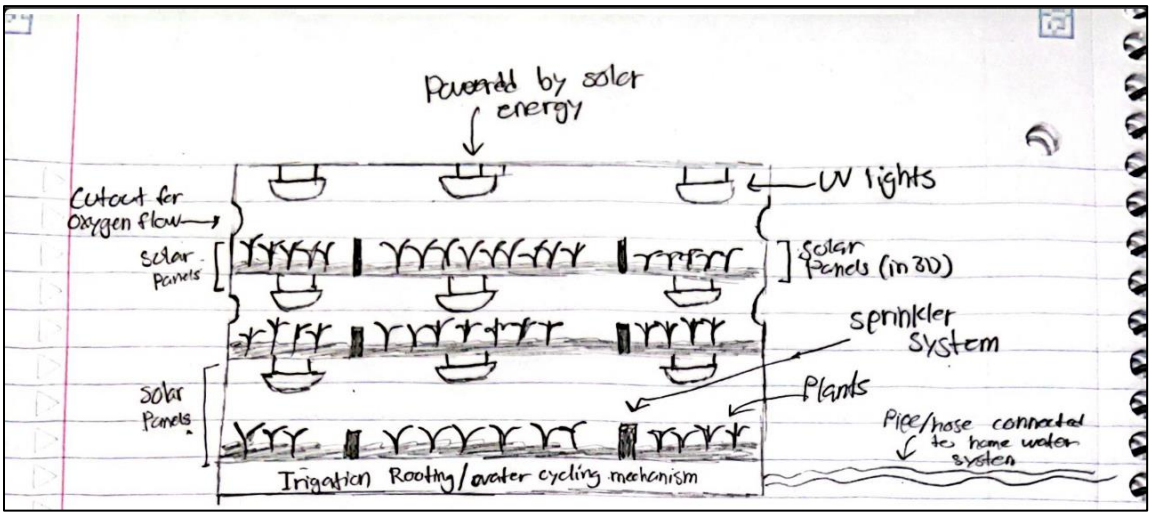

Figure 5. Concept Sketch 3

The team's third sketch allows the user to have a lesser financial responsibility because it is powered by solar energy, which excludes the user from the need to plug the device into their homes which would ultimately raise the user's energy bill. Furthermore, the team's device is irrigated using the user's home water source connected to the embedded sprinkler system. This sketch also allows for customizability because the user is not required to have three levels but can choose to use different levels for separate household items or exclude them altogether.

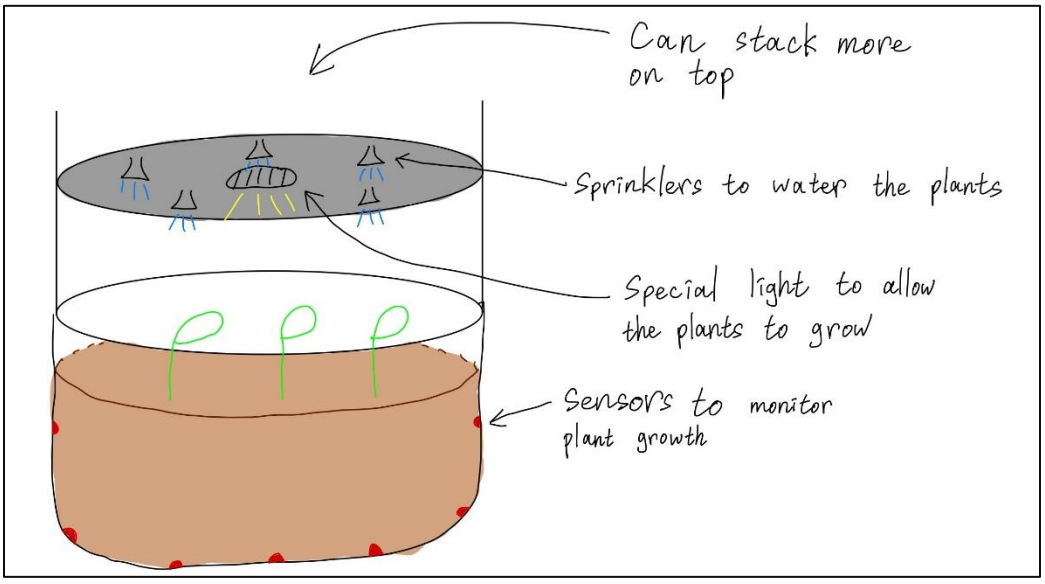

Figure 6. Concept Sketch 4

The team's last sketch incorporates sensors that automatically monitor plant growth and make automatic adjustments to the light level and amount of water based on the plants' conditions. The

light is a UV light bulb that will allow the plants to grow even with low sunlight exposure. The design is also modular, and the users can add more layers on top of the existing ones.

2. Concept Selection

a. Down-Selecting to Two Concepts

After discussing and comparing the different concept sketches, the team narrowed the options down to concept sketch 2 (See **Figure 4.**) and concept sketch 3 (See **Figure 5.**). These sketches satisfy the user needs in a practical and efficient way. Concept sketch 2 is a highly customizable design that supports any plants and allows the users to add more layers if they want. It also has an automatic watering and lighting system that makes adjustments based on the plants' conditions. Concept sketch 3 has similar features to concept sketch 2, but it's less modular and doesn't support the same number of plants. It also incorporates solar panels to reduce the cost of maintaining the system.

b. Pugh Scoring Matrix

		Reference		Concept 1		Concept 2	
User Needs	Weight (1-5)	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Low maintainance	5	3	15	4	20	3	15
Reliabiltiy	4	4	16	5	20	4	16
Customizability	3	3	9	4	12	4	12
Automatic monitoring	2	2	4	4	8	4	8
Alerts and notifications	1	3	3	3	3	3	3
Aesthetics	0	4	0	5	0	3	0
TOTAL			47		63		54

Figure 7. Pugh Scoring Matrix

Reference is the Hydroponics Growing System from **Table 2.** Concept 1 is from **Figure 4.** Concept 2 is from **Figure 5.**

After carefully analyzing concept 1 and 2 and comparing with the reference product, the team found that concept 1 satisfies most of the user needs in an efficient and practical way and receives the highest total score of 63. The lower rating for alerts and notifications is partly due to the app not being developed yet. Concept 2 satisfies most of the user needs as well and received a score of 54 but is lacking in some areas compared to concept 1.

c. Final Concept Selection

After reviewing the Pugh Scoring Matrix and careful consideration, the team decided to use concept sketch 2 (See **Figure 4.**) as their final concept sketch. This sketch satisfies all the user needs practically and efficiently. It has low maintenance, high reliability, and high aesthetic appeal. It's very customizable and supports most types of plants. It's a modular design, which allows the user to add more layers depending on their needs. It has an automatic watering and lighting system that makes adjustments based on the plants' conditions. It also alerts and notifies the users through a mobile app whenever any problems arise.

3. Grand Concept Design

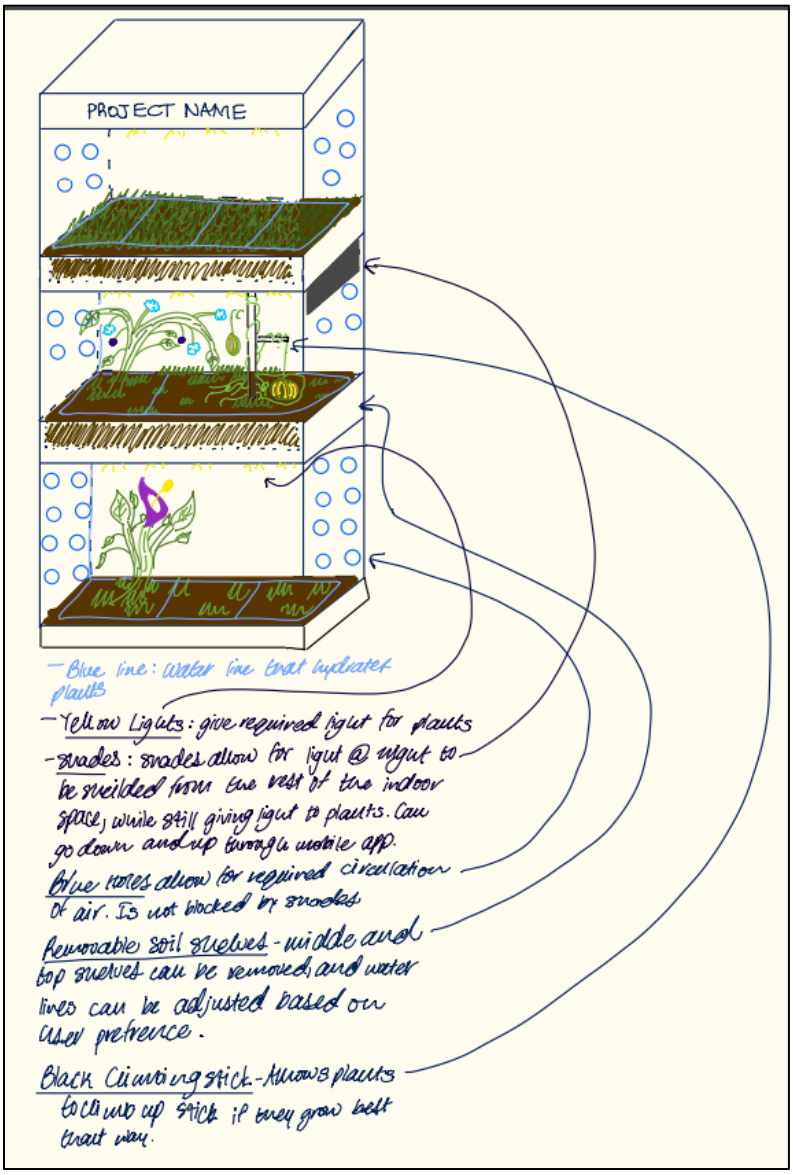

Figure 4. Concept Sketch 2

This design of the indoor plant growing system features multiple layers that each have soil in them to provide growth for the plants. Each layer is modular and highly customizable, allowing users the freedom to add and remove layers based on their needs and desires. A three-layer shelf will have a height of roughly 20 inches, with each layer being 6.5 inches high, and a 6 by 6 inches base, so it doesn't take up too much space while still providing enough space for the plants to grow effectively.

There will be a UV light on the roof of every shelf connected to a sensor that automatically turns the lights on and off based on the user set time. There will be blinds on each side panel that cover the lights based on the user's preference. There will also be holes on the sides of the walls to provide air circulation for the plants. A soil sensor is also used to monitor the moisture and

temperature levels and adjust the watering schedule accordingly, ensuring that the plants receive the right amount of water based on their specific needs.

4. Prototyping Design

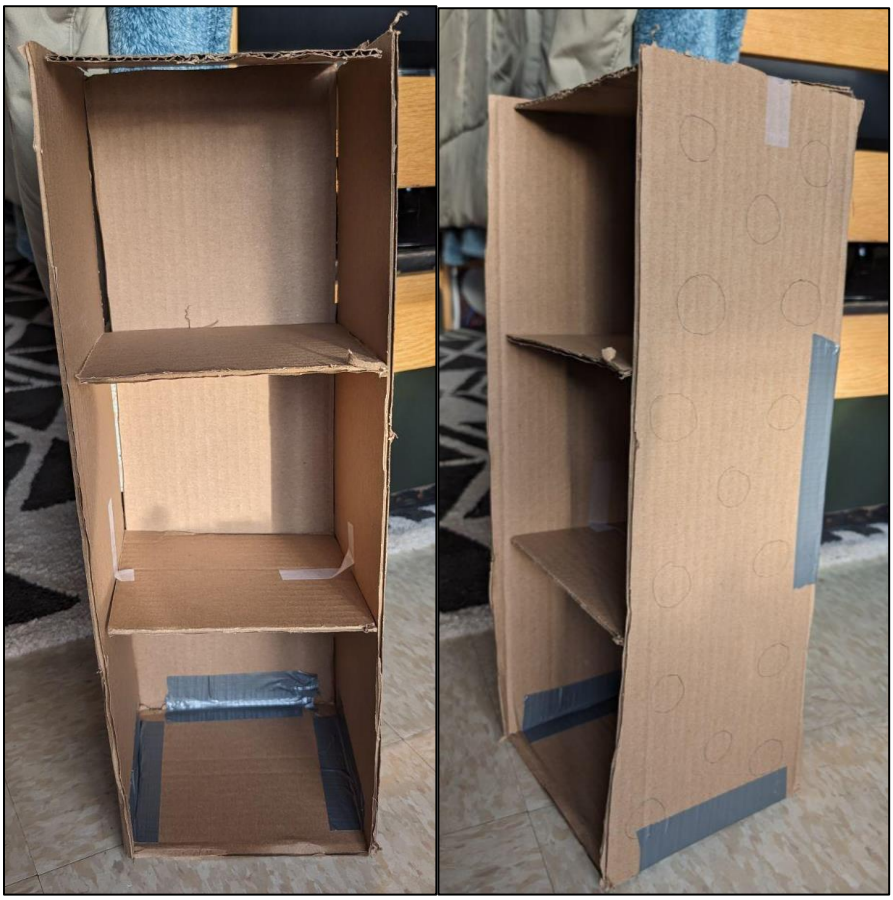

Figure 8. Prototype Mockup

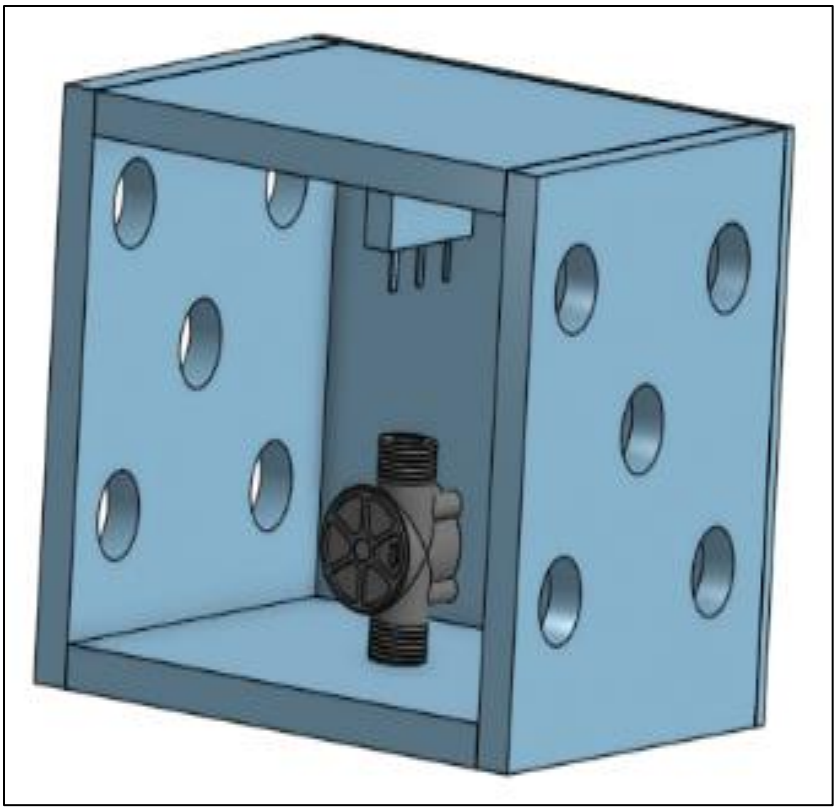

Figure 9. Prototype CAD Model 1.0

a. Description of Prototype

The team's prototype mockup is a very basic level mockup that models the general shape of the plant shelf and provides a better starting point for potential improvements in the product's design. The main limitation the team has with the mockup is not having access to the sensors needed for the final product to function properly. The team's CAD model of the prototype is a modular version of the design, for it can be stacked on top of itself to accommodate more plants. The design has an equal amount of air filtration holes on each side of the prototype to provide ample amounts of oxygen to the inside of the indoor gardening system. The system is equipped with a top mounted UV light to promote plant growth, as well as a built-in watering irrigation system mounted to the bottom to equally water each plant. The front panel is made of glass to allow users to observe the inner workings of the plant shelf.

Limitations

Some limitation of the product includes having a low budget, limited items, and access to materials. Tight time constraint will also pose somewhat of an issue and the team will have to find a way to get things done in a timely manner.

b. Prototype Design Requirements

Table 3. Requirements

Requirements	Ideal Value	Value Range
Measure and monitor the plant light level	Best light level is around 150 foot-candles	Light level range is around 100-200 foot-candles
Plant has good durability	Doesn't break from at least 6 ft	Drop test from 3-10ft
Measure and monitor the soil moisture	Best soil moisture level is around 45%	Soil moisture level range is around 20-60%
Measure and monitor the plant temperature	Best temperature is around 75°F	Temperature range is around 70-80°F
Plant shelf has light level controlled parts	Parts should work correctly around 95% of the time	Range that the parts work correctly is around 80-99%

These requirements are crucial for the product to function properly. Ensuring that they are properly implemented is key to the success of the product. During the design process, the team will implement each requirement individually, and then thoroughly test and examine each requirement to eliminate any potential errors. The team will also reference **Table 3.** throughout the design process and make any changes accordingly.

c. Testing Methodology and Verification Plan

The team will conduct tests including:

- Utilizing a light sensor to measure the amount of light intensity in different areas of the shelf.
- Durability tests such as mechanical stress that replicate conditions of continuous use.
- Checking the accuracy of the soil moisture sensor by comparing the results to observations made manually.
- Utilizing equipment such as a water level sensor to measure the accuracy of water dispensing.
- Utilizing a thermometer to measure the plant temperature and comparing the data to the optimal temperature.
- Measuring the light controlled parts' reaction time using a stopwatch and sensor feedback and comparing the data to the optimal reaction time.

At least three runs of each test are necessary to guarantee reliability and consistency.

d. Correlation Matrix and Verification Scorecard

Design Requirements / User Needs Correlation Matrix								
	Measure light level	Durability	Measure soil moisure	Measure temperature	Light controlled parts	Requirement 6	Requirement 7	User Need Weight
Low maintenance	9	3	9	9	3			5
Reliability	3	9	3	3	1			4
Customizability	0	0	0	0	3			3
Automatic monitoring	9	0	9	9	1			2
Alerts and notifications	1	0	1	1	1			1
Aesthetics	0	0	0	0	0			0
Need 7								
Importance ->	76	51	76	76	31	0	0	

Figure 10. Correlation Matrix

Verification Scorecard Points Distribution*		
	Raw Percentage	Score Card Points (25)
Measure light level	24.5%	6
Durability	16.5%	4
Measure soil moisure	24.5%	6
Measure temperature	24.5%	6
Light controlled parts	10.0%	3
Requirement 6	0.0%	0
Requirement 7	0.0%	0
This sum should be 25! --------->		25

Figure 11. Scorecard Points Distribution

Scorecard			
Requirement	Range	Score Rubric	Score
Measure light level	100-200 foot-candles	0 points - light level is under or above the range 4 points - light level is around the lower or upper bound 9 points - light level is around the middle of the range	6
Durability	3-10 feet	0 points - survives from a drop of 3 feet 4 points - survives from a drop of 6 feet 9 points - survives a drop of 10 or more feet	4
Measure soil moisure	20-60% moisture level	0 points - moisture level is under or above the range 4 points - moisture level is around the lower or upper bound 9 points - moisture level is around the middle of the range	6
Measure temperature	70-80°F	0 points - temperature is under or above the range 4 points - temperature is around the lower or upper bound 9 points - temperature is around the middle of the range	6
Light controlled parts	80-99% to work properly	0 points - working probability is under 80% 4 points - working probability is around 80% or slightly greater 9 points - working probability is around 99% or greater	3
Requirement 6			0
Requirement 7			0

Figure 12. Scorecard

After each iteration of the design process, the team will apply the rubric to the implementations of the requirements to see how they score, what they lack, and make any changes based on the results. The team will repeat this process until the highest score for each implementation is achieved and the requirements are fully satisfied.

e. Protype Preliminary Design and Mock-up

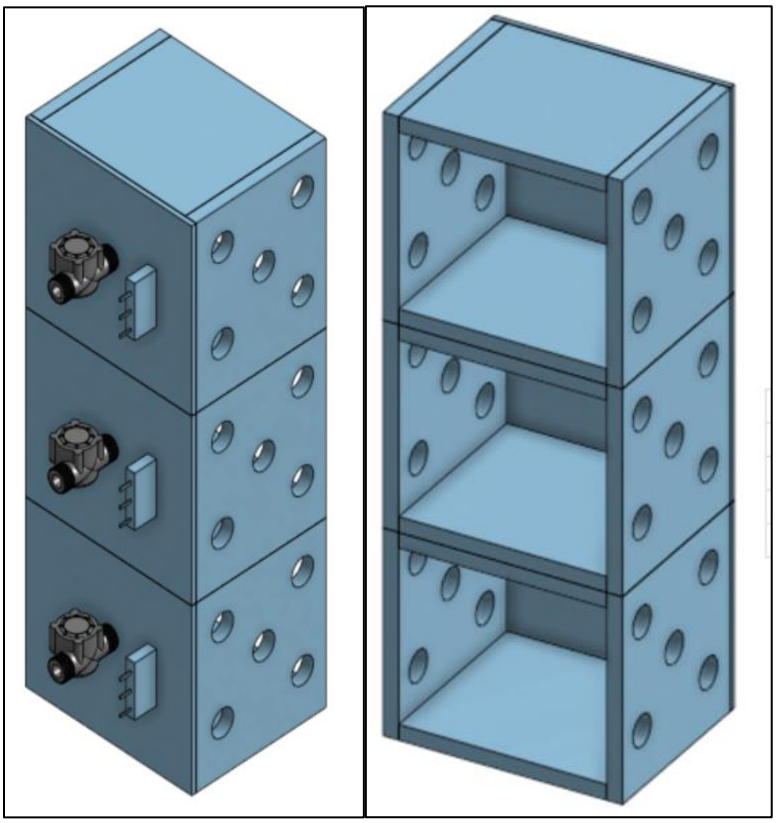

Figure 13. Prototype CAD Model 1.1

The team had updated the design of the CAD model of the prototype based on the feedback received during team discussions. The team changed the location of the UV light and the watering system from inside the plant shelf to the back. The team also added two more layers of the plant shelf on top of the preexisting one.

Detailed Design Review

1. Prototype Fabrication and Evolution

In the beginning the team conducted some basic research on at home plan growing and different systems that are used. The team wanted to try and improve on the current existing products to make them more user friendly, reliable, and customizable. The process first included making a basic mockup of the product out of cardboard. On Onshape, all the parts of the prototype were made and assembled together as shown in the prototype appendix. After all the parts arrived and were made, the team put together the product using different machines and putting it all together.

2. Detailed Design

a. Final Prototype Design

To address user wants, market expectations, economic concerns, and social impact goals, the Final Prototype design includes important research and development findings. To answer the main problems of the intended audience, it emphasizes aspects like minimal maintenance, reliability, and customization. It intends to set itself apart by providing special features and filling gaps in the market, based on market research. In addition to minimizing production costs, the design focuses on sustainability and urban life. It combines environmental sustainability and inclusion while also taking social effects into account. The prototype successfully satisfies expectations as shown in the Appendix's drawings, which allows fast manufacture and assembly.

b. Revised Grand Concept Design

Originally, the team had planned to implement curtains that shielded light from reaching the surrounded area according to the desired times of the user. However, with the lack of time, the team decided to make these curtains manually operated. Other than this, The team has not made any major changes to the original design concept.

1. Final Prototype Verification

The final prototype verification went smoothly, and the team was able to test the final prototype to see how it would function in the real world, identify any unexpected outcomes and identify any areas that can be improved. The final prototype is very sturdy and is holding together very well. The prototype provides a highly accurate look of what the real product should look like and provides deep enough soil depth for the roots of the plants to grow comfortably. The light source is working correctly and turns on and off based on a previously set timer. The soil sensor is working correctly as well and accurately measures the soil's moisture level and temperature. The team encountered some problems with the water pump and couldn’t get it to function as expected. The pump didn’t turn on correctly and wasn’t able to be controlled based on the moisture level from the soil sensor.

Figure 14. Final Prototype

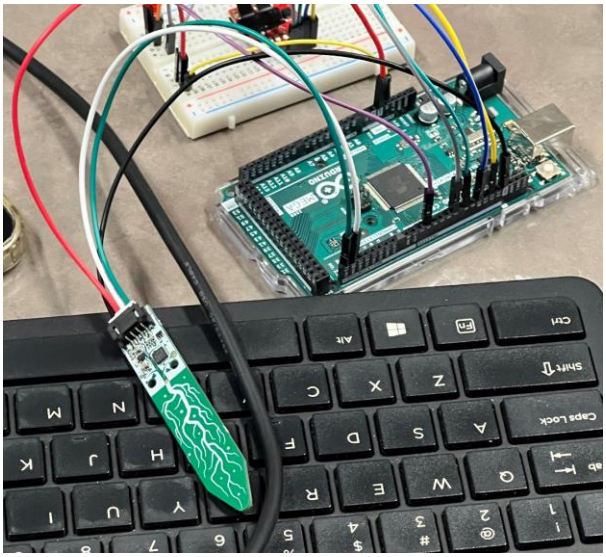

Figure 15. Arduino Circuit of the Final Prototype

2. User Validation

The top three user needs the team determined through research and the pairwise comparison chart, **Figure 2.**, include:

1. **Low maintenance -** Having low maintenance allows the users to grow their plants effortlessly and without any hassle.
2. **Reliability -** Having good reliability ensures the users' plants will be healthy and thrive.

3. **Customizability -** Having customizability allows the users to grow whatever plant they want and whenever they want.

The team intends to use multiple approaches to address the concerns and include ethical considerations in the user validation plan. Firstly, to collect quantitative data on users' opinions regarding the effectiveness of the plant shelf in simplifying plant growing and whether the top three user needs are met, a structured survey/questionnaire will be used. After providing their prior informed permission, people will answer the questions, and any personal information gathered will be anonymous to protect privacy. To learn more about the experiences and viewpoints of the users, semi-structured interviews will also be held. Throughout the interview, the users' privacy and rights will be respected and they are allowed to opt out anytime and for any reason. Finally, to get quick feedback on the functionality and performance of the product, in-person prototype testing sessions will be held to watch people engage with the finished product. Participants will be properly informed of the testing sessions' goals and data processing procedures. Through analysis of the data, the team will determine how well the suggested solution addresses the problem at present, satisfies user requirements, and adds value for the users.

3. Value and Impact

Economic sustainability depends on finding a balance between income and expenses. Development, production, marketing, and research & development are the initial startup costs. The costs of continuous manufacturing need to be professionally managed. Direct sales, collaborations, and data monetization are some of the ways that businesses might make money. There might be funds offered, depending on the social objective. It is important to find a balance between financial sustainability and social effect. The long-term viability of the business plan requires regular assessment and modification.

The proposed solution's implementation might have an important social impact, both good and bad. On the positive side, it might promote home production of fruits and vegetables, which could lead to better overall health. This is especially beneficial for people who have limited access to fresh produce or are struggling financially. It could also reduce financial strain and promote social connections. However, there is a chance of social exclusion and technological limitations for specific populations and environmental issues. Therefore, to maximize benefits and reduce problems, significant planning and preventative measures are needed.

	Value Categories	
Stakeholders	Economic	Social
Families	*Reduce cost of fresh produce. Cost more to maintain the shelf*	*Reduce time to go to grocery story. Reduce social interactions*
Supermarkets	*can offer resources that support at home growing. Lose money*	*healtheir eating habits.Not many people going to the store*
Food providers	*More sales of healthy food. Fluctuations inprice*	*Acess to nutritious food. Might market unhealthy food*

Figure 16. Value Impact Matrix

4. Project Recommendations and Next Steps

While the product has fulfilled most of the requirements, we had placed to fulfill its purpose, there are still ways to improve the product. Firstly, due to the Smith Lab workshop not making the correct measurements, the components of the Bloom Box don't have optimal fitment.

Without near air-tight fitment and already having implemented ventilation, the plant and its soil could suffer significant losses to its plant growth. So, it is recommended that a 2nd prototype is made to have the correct measurements. Once this is done, it is also recommended to test a variety of plants growing in the Bloom Box: fruits, vegetables, and plant varieties that can fit within a 6x6x3 box of soil. Since our product is meant to grow plants, it is critical that the soil sensor, light, and curtains are tested in conjunction with each other, to make sure the Bloom Box is a working product and does function to the standard of its advertisement.

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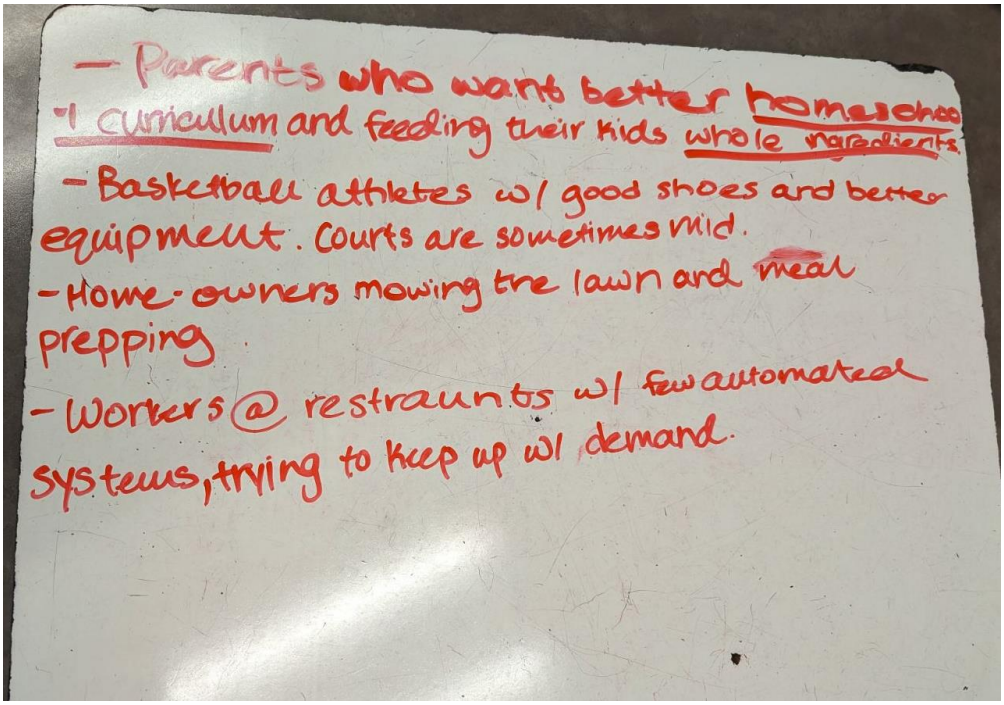
Appendix A. Evidence of Brainstorming



Appendix B. Research Methodologies

Summary

Interview went very well, as we talked for almost an hour versus the allotted time of 10 minutes. I introduced myself, talked about the segment of the project she would be helping to complete this interview, as well as letting her know she can opt out of any questions I ask at any time. After a few questions, I found that she used to be a professional chef, went to culinary school, and proceeded to work at high end restaurants. However, when it came time to have a family, she became a stay-at-home mom and now enjoys her life using the skills she acquired to cook good healthy food for her family of 4 and friends. But she had a lot to say about how the quality of food that we buy in supermarkets prevents the nutritional benefits of quality food and her skills from shining in her food. She wishes that there was a way to obtain good, whole, unprocessed ingredients without paying an unsustainable amount of money on quality ingredients. Having knowledge of the unnecessary chemicals/oils that detriment our food, she wants to feed herself and her family the minimally processed foods that will improve their health. Having taken notes on the matter, I moved onto what she does in her daily life and found that she homeschooled both of her children. As she values the Christian faith to the number one priority, she homeschools her children in a way that instills the Christian without paying for a private school. As an interviewer, I've heard her reasons for doing this in people that I've met and across the internet, and confirmed that there is an audience out there, Christian and/or not Christian, that values taking responsibility for their child's education. She wishes however, that there were better ways of obtaining the curriculum that aligns with her children's unique learning styles and environment, as she has not found this very accessible. Writing this down, I saw that the phone call lasted for almost an hour and wrapped things up.

Questions Asked

Can you tell me a little about yourself?

What do you do for a living?

What are some of your hobbies?

What does your typical day look like? What are some daily tasks that you perform throughout your daily routine?

What isn't working about how you handle getting whole sustainable ingredients to cook with?

What products for homeschool curriculum do you wish were available that are not?

Responses

Can you tell me a little about yourself? What do you do for a living? - My name is Sarah _____, I am a stay-at-home mom of 2 children, living in Dallas Texas. I'm Haitian, in my mid-thirties, and a Christian looking to raise my family in the faith.

What are some of your hobbies? – I love reading. While I still read the Bible regularly, I used to be an avid reader, but life raising kids and homeschooling sometimes got in the way. I want to

get back into it, but for now I mostly listen to audio books. I still like the old-school book with ink. I also love cooking. I used to be a professional chef and I loved being able to put my heart and soul into food that people in enjoy. But wanting to raise I family I became a stay at home mom, living out my passion for cooking in my home for friends and family that I love. Having a background in cooking however makes going out very fun, critiquing different foods and finding out what dishes do and don't need. I enjoy it.

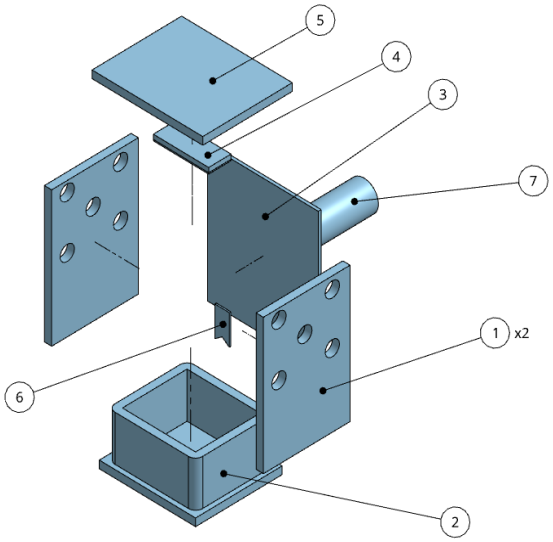
After a little bit more conversation, I asked…

What isn't working about how you handle getting whole sustainable ingredients to cook with? - Well, the truth is I don't handle it very well. Because getting whole foods is so expensive, most times I must give into getting processed foods for my family. It's hard to be healthy. My mentality is that my kids need to be able to grab snacks, so I give them processed apple sauce, chips, alongside fresh fruits, and veggies to hopefully balance things out. We aren't broke, but we aren't trying to drain our resources. The cost of one apple is like 2 bucks sometimes. The organic market in the US is not as regulated as we would like it to be. What we allow in our foods in this country is so different from that of other countries. When I went back to Haiti to spend time with my mother, I was able to eat organic because that's all they had there, and I lost a ton of weight. But I can't do that here. Even if I wanted to, I couldn't do urban gardening. It's very expensive, for very little profit.

After that, we started talking about her day-to-day life, and she mentioned homeschooling her younger son, Liam. After about 10 minutes I asked…

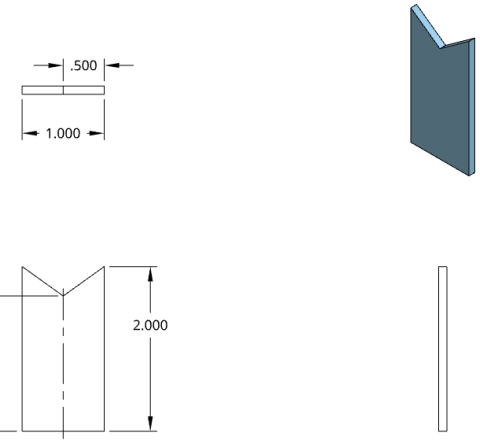
What products for homeschool curriculum do you wish were available that are not? – I'm currently teaching my son, Liam, math, and arithmetic. I do this because I don't want to enroll him in the school system currently, and I want to raise him in a Christian environment where His faith leads Him to solve problems. However, the problem is that you can spend a ton of money on curriculum but find out that the curriculum doesn't work for your kid. From textbooks to workbooks, I've spent a lot of time and money to find the right resources for him, but they aren't as accessible or as easy to find as you might imagine. So, the question is how one can compile all this information into one place so that parents can have a way to specialize their child's curriculum.

Appendix C. Prototype Working Drawing Packet

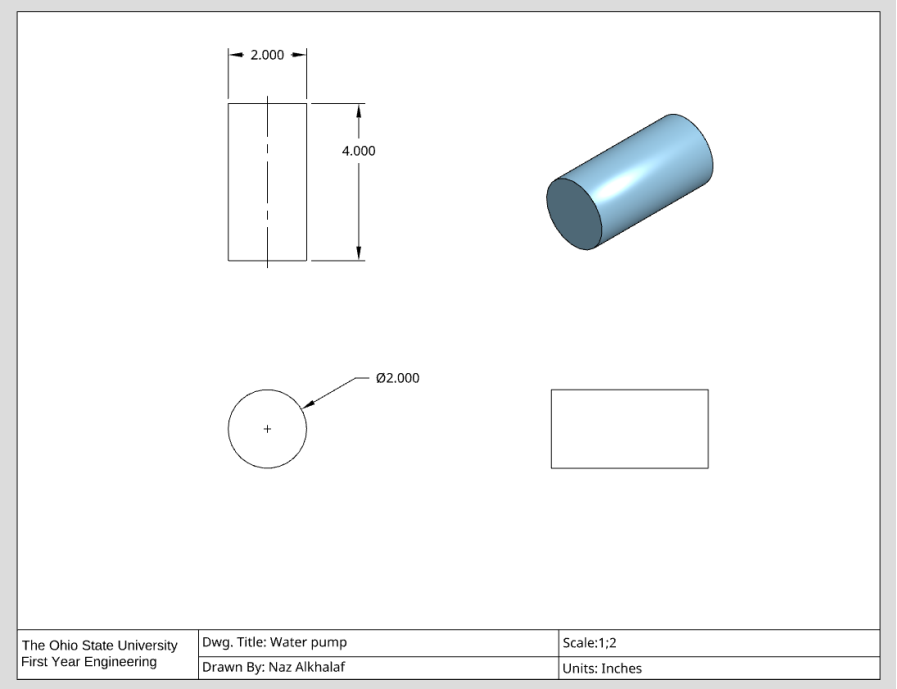


Item	Quantity	Name
1	2	Side panel
2	1	Bottom panel
3	1	Back panel
4	1	Light
5	1	Top panel
6	1	Soil sensor
7	1	Water pump

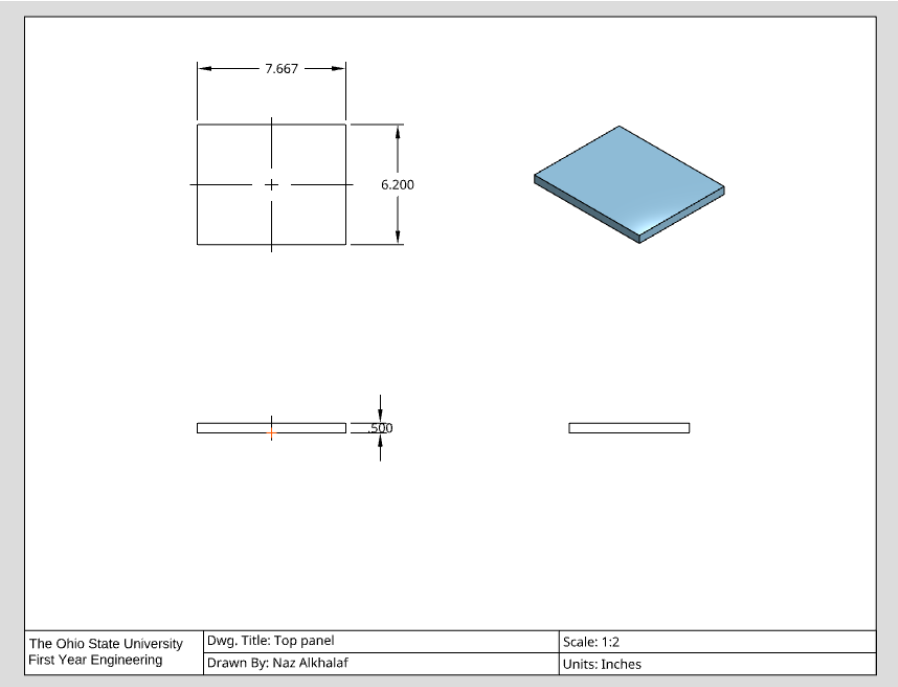
The Ohio State University First Year Engineering	Dwg. Title: Product exploded view	Scale: 1:4
	Drawn By: Naz Alkhalaf	Units: Inches



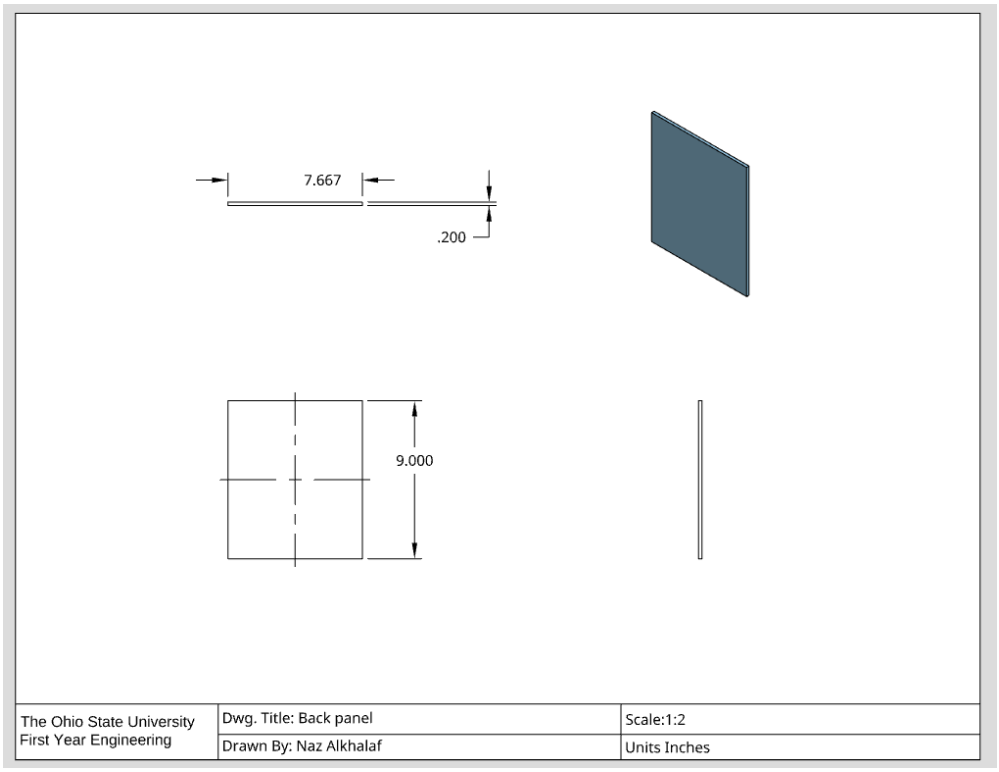
The Ohio State University First Year Engineering	Dwg. Title: Soil sensor	Scale:1:2
	Drawn By: Naz Alkhalaf	Units: Inches



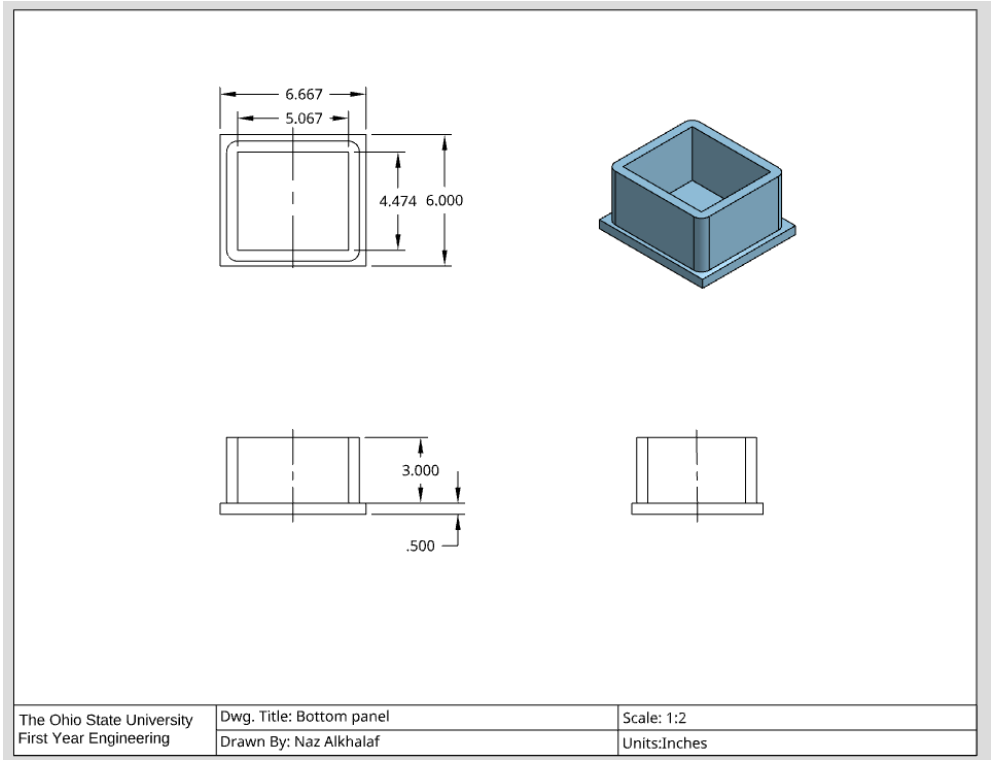
The Ohio State University First Year Engineering	Dwg. Title: Water pump	Scale:1;2
	Drawn By: Naz Alkhalaf	Units: Inches



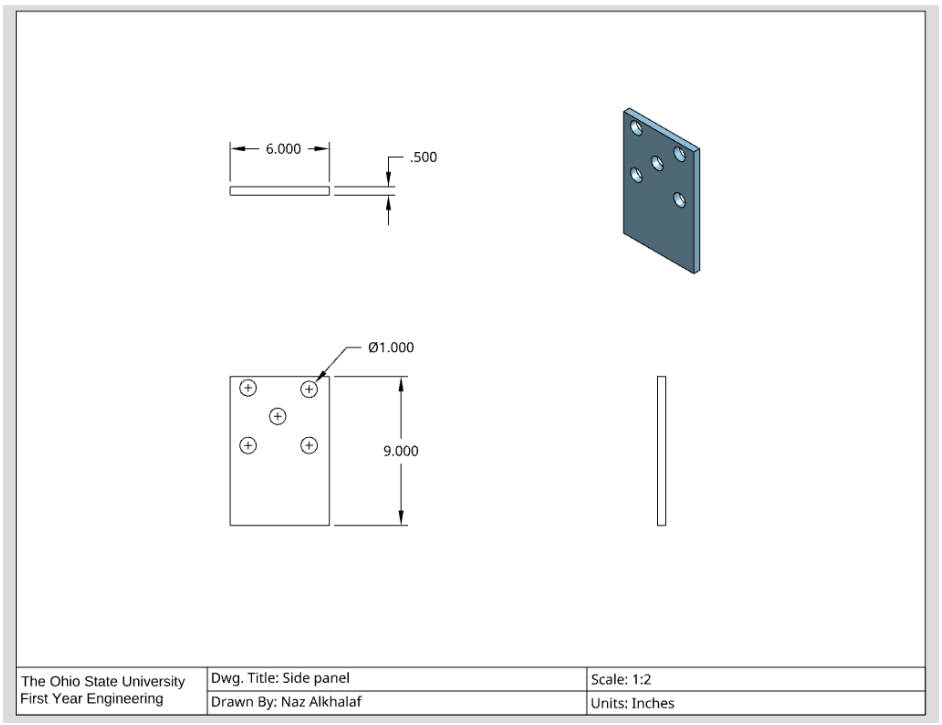
The Ohio State University First Year Engineering	Dwg. Title: Top panel	Scale: 1:2
	Drawn By: Naz Alkhalaf	Units: Inches



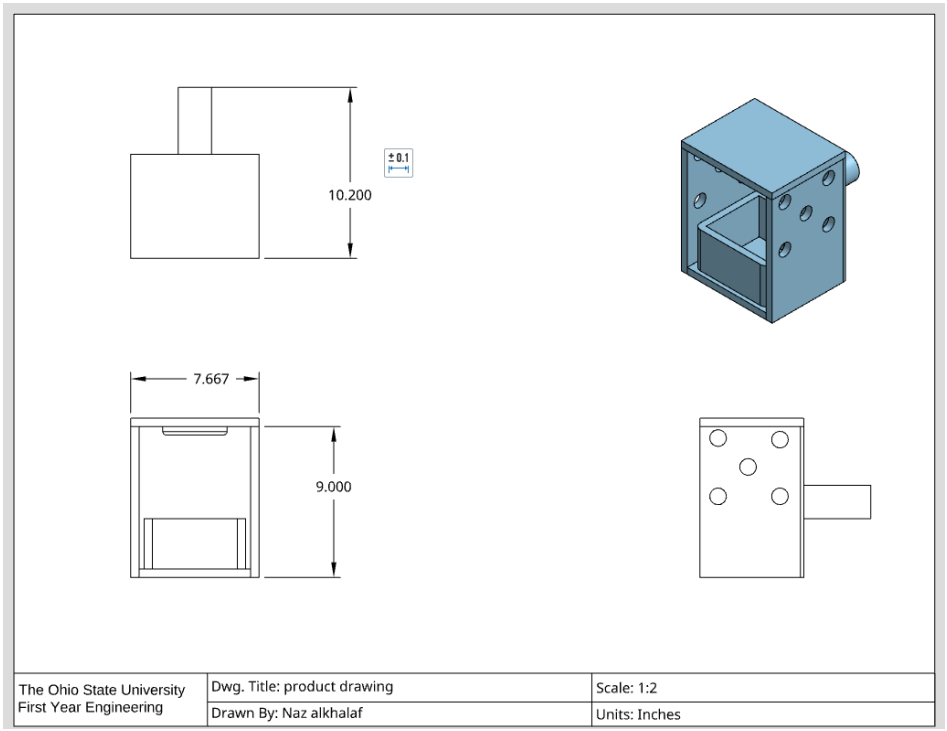
The Ohio State University First Year Engineering	Dwg. Title: Back panel	Scale:1:2
	Drawn By: Naz Alkhalaf	Units Inches



The Ohio State University First Year Engineering	Dwg. Title: Bottom panel	Scale: 1:2
	Drawn By: Naz Alkhalaf	Units:Inches



The Ohio State University First Year Engineering	Dwg. Title: Side panel Drawn By: Naz Alkhalaf	Scale: 1:2 Units: Inches



The Ohio State University First Year Engineering	Dwg. Title: product drawing Drawn By: Naz alkhalaf	Scale: 1:2 Units: Inches

Appendix D. Software Code (if applicable, remove if not used)

```
#include "Adafruit_seesaw.h"

int buttonPin = 3;

Adafruit_seesaw soilSensor;

void setup() {
  Serial.begin(9600);
  // Controlls the soil sensor
  if (!soilSensor.begin(0x36)) {
    Serial.println("ERROR! seesaw not found");
    while(1) delay(1);
  } else {
    Serial.print("seesaw started! version: ");
    Serial.println(soilSensor.getVersion(), HEX);
  }
}
void loop() {
  // Controlls the LED
  pinMode(buttonPin, OUTPUT);
  digitalWrite(buttonPin, HIGH);
  delay(10000);
  digitalWrite(buttonPin, LOW);
  delay(10000);
  // Controlls the soil sensor
  float tempC = soilSensor.getTemp();
  uint16_t capread = soilSensor.touchRead(0);
  Serial.print("Temperature: "); Serial.print(tempC); Serial.println("°C");
```

```
  Serial.print("Capacitive: "); Serial.print(capread); Serial.println("200 (very dry) to 2000 (very
wet)");

  delay(5000);

}
```

Appendix E. Additional Raw Data

Appendix F. Project Management Schedule and Meeting Minutes

3. Project Schedule

	Project Start Date	Project End Date	Today's Date
	1/8/24	4/22/24	4/3/24
Task Description & Lead Initials	Start Date	End Date	% complete
Creating concept sketches for the final product (OC)	2/13/24	2/20/24	100
Creating a mock-up for the product (NA, OC, JJ, JL)	3/12/24	3/19/24	100
Determines the requirements for the product (JJ)	3/19/24	3/26/24	100
Creating a CAD model for the product (NA)	3/12/24	3/19/24	100
Ordering custom parts for the final product (JJ)	3/20/24	3/22/24	100
Coding for the final product (JJ)	3/27/24	4/22/24	10
Creating the basic structure of final product (NA, OC, JJ, JL)	3/15/24	4/22/24	15
Adding the sensors for the final product (NA, OC, JJ, JL)	3/29/24	4/22/24	0

Figure 17. Gantt Chart

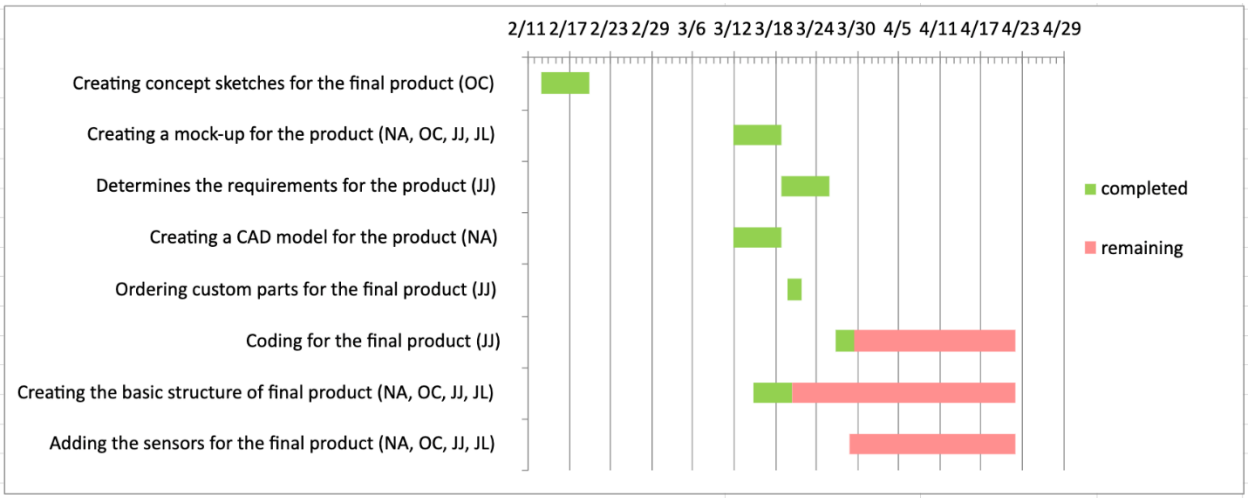


Figure 18. Gantt Chart Graph

Potential challenges

- Coding the sensors correctly
- Putting together the product
- Testing and making sure the product works
- Implementing the soil into the shelf

Major project deliverables

The goals of the team are to be able to get all our parts for the product and meet all the requirements. Coding for the final product is also something that needs to be worked on and done soon for the sensors in the product. The deliverable of the product will be the cad model and the mockup.

4. Prototyping Workday 1 Meeting Minutes

The tasks that our team completed today include ordering our parts that we need for our product and making a finishing cad model. The data that we were able to collect today include using laser cutter for the side parts of our product and using Arduino for the water and light sensors. We still need to figure out the code to get the sensors working and we also need to know what material we will be using for our product. For our next meeting we want to be able to work with our product hands on and see what we have to work on and improve.

Date/time	Location	Members attended	Objective statement	Completed tasks	Tasks to be completed	Project timeline	Decisions made
04/1/24	In class	All	The purpose of this meeting was to talk about making our product	Final prototype-completed by all	Putting prototype together-all	Get our items that we bought and work on making the product	We will all try to work with the product and use our skills for everything

5. Prototyping Workday 2 Meeting Minutes

Date/time	Location	Members attended	Objective statement	Completed tasks	Tasks to be completed	Project timeline	Decisions made
04/12/24	In class	All	Work on the prototype	Finished making the prototype	Finish the writing report of the product and the coding part	Put together the sensors into the product	We will try to make the code for the sensors

6. Prototyping Workday 3 Meeting Minutes

Date/time	Location	Members attended	Objective statement	Completed tasks	Tasks to be completed	Project timeline	Decisions made

04/15/24	In class	All	Work on the coding for the product	Finished making the prototype	Finish the writing report of the product and the coding part	Put together the sensors into the product	We will try to put the sensor in and use for the product

7. Prototyping Workday 4 Meeting Minutes

Date/time	**Location**	**Members attended**	**Objective statement**	**Completed tasks**	**Tasks to be completed**	**Project timeline**	**Decisions made**
04/17/24	In class	All	Work on the coding for the product	Made the code for the light sensor	Make code for the soil and water pump	Put together the sensors into the product	We will try to put the sensor in and use for the product

Appendix G. Team Working Agreement

Team Working Agreement

Spring 2024
01/22/2024

1. Team Information

Course Section # (see Carmen) 8189
Team Designation (Table Letter) Table P
Instructor and GTA Dr. Bailey Braaten and Ajay Anandh
Team Name (Optional)

Contact Information:

Name	Email Address	Phone Number
Naz Alkhalaf	Alkhalaf.10@buckeyemail.osu.edu	6148129453
Justin Lewis	Lewis.3402@buckeyemail.osu.edu	5132120643
O'Brein Carr	Carr.985@buckeyemail.osu.edu	4699873200
Jerry Ji	Ji.680@buckeyemail.osu.edu	9378186991

2. Team Values & Goal

What are the team's top 5 values?

Teamwork, family, accountability, compassion, and health.

What are the team's expectations of quality level? Top goals? Minimum acceptable goals?

We expect to give our best on each assignment that we do. At a minimum we expect to finish the assignment and turn it in on time.

Include at least 1 goal regarding psychological safety, belonging, and inclusion.

We want to treat everyone with respect and make everyone feel included. We want to complete every project and assignment this semester to the best of our abilities and turn them in on time. We want to design and create a product that could potentially be used to solve a real-world problem by the end of the semester.

3. Communication and Meetings

What are your team's preferred method(s) of contact and expected response time(s)?

We will make a group chat. We expect to respond whenever we are available.

How often do you plan on meeting to achieve your goals? (Do you anticipate this changing throughout the semester?)

It will depend on the project and how long it will take to complete it, but we will try to meet at least once a week to make sure we are on track. However, we expect this to change throughout the semester.

Primary and Secondary Meeting Day/Time/Location

We will meet at The Union or one of the libraries at the date and time based on everyone's availability for that week. We will meet on Zoom if everyone is unavailable.

Individual(s) in charge of agendas, reminders, minutes

Justin Lewis, Jerry Ji, Naz Alkhalaf, O'Brein Carr

4. General Expectations and Group Norms

How are team members expected to behave? What are the group norms?

We expect team members to behave accordingly based on the assignment or project and do the parts they are assigned to do.

What are acceptable/unacceptable types of interaction?

Physical and verbal altercations and not doing your part on an assignment or project are unacceptable behaviors. We expect to treat each other with respect.

What are team members' expectations regarding attendance?

Show up to class everyday unless there is a valid excuse such as being sick.

How are team members expected to behave during lab/class periods?

Everyone should do their part on an assignment or project and what we agreed upon.

What are team members meant to do between classes? Lab/class preparation?

Finish any work they are responsible for and make sure to come to class prepared and not fall behind.

How are team members meant to ensure the team stays on track?

Text each other on the group chat to make sure everyone is doing their job correctly.

How are documents expected to be shared? (e.g. OneDrive, Google Docs, etc.)

Word, Goole Docs, Gmail, Buckeyemail, and OneDrive.

How many days before an assignment is due should everybody have their portion completed for review?

At least 1 day before the assignment is due.

When should team members first notify the group if they are struggling?

As soon as possible to make sure that they don't fall behind.

5. Individual Team Member Responsibilities

When/how will individual tasks/responsibilities be assigned?

We will assign tasks and responsibilities during the team meetings and through text. Tasks and responsibilities will be assigned based on each team member's skills and strengths and what they want to do.

How will the team ensure work is divided and that everyone participates equally?

We will define everyone's roles for an assignment or project clearly. We will check in with each other regularly either during team meetings or by text.

Are there specific roles that all team members have?

~~Jerry Ji and O'Brein Carr~~ Justin Lewis and Naz Alkhalaf will keep track of the deadlines and communicate with everyone about the progress of assignments and projects. ~~Justin Lewis and Naz Alkhalaf~~ Jerry Ji and O'Brien Carr will overlook assignments and projects to ensure we are on the right track and are doing well on them.

What specific tasks are team members in charge of?

~~O'Brein Carr and Naz Alkhalaf~~ Jerry Ji and Justin Lewis will work on coming up with what to write in our documentation. ~~Jerry Ji and Justin Lewis~~ O'Brein Carr and Naz Alkhalaf will work on revising the documentation.

How often will these roles/task rotate?

These roles and tasks will rotate every assignment or project.

6. Conflict Resolution

Suggested Statement: Once the team goals, general member expectations, and individual team member responsibilities have been established, candid, non-threatening discussion must be held when the group or individuals are not meeting the agreed upon terms.

When there is disagreement amongst members, how will the team make decisions?

The team will hold meetings to discuss and figure out the best way to resolve the disagreement.

How will team members above be held accountable (be specific!)?

The person held accountable will have to finish whatever they are working on and there will be help provided if they are stuck. There will be more check-ins for that person in future assignments.

How will team members that are not meeting expectations (not contributing to the team effectively) be addressed?

We will discuss the issue with said person and come up with potential solutions either through text or during team meetings. We will also provide help if the person needs assistance with something.

How will team members that are not interacting appropriately with team members be addressed?

We will tell said person to stop what they're doing, be respectful, and not say certain things.

How will the team handle resolving issues when a team member is not acting inclusively?

We will tell them to cut it out, discuss the issue, and come up with potential solutions during team meetings or by text.

What are the consequences for violating this agreement (be creative!)?

Whoever violates these agreements must do more work and put in more effort in upcoming group assignments. There will also be more check-ins for said person.

When is it okay to redefine goals, expectations, and responsibilities?

Whenever our group thinks that what we are doing is not efficient enough and is not producing the desired results.

When will UTAs, GTAs, or the instructor become involved?

Whenever a group member is not cooperating even when told to do so multiple times and the team can't come to an agreement on an issue.

7. Expectations of Faculty and GTAs

Suggested Statement: If a team member fails to live up to this agreement, the situation may be reported to the staff, but the team will still be responsible for submitting a completed assignment. Staff will be available to meet with teams to resolve issues.

Faculties and GTAs are expected to help the team come up with solutions for conflicts that the team can't resolve and get the team back on track.

8. Team Signatures

_____Jerry Ji_____
Name

____Naz Alkhalaf_____
Name

_____Justin Lewis_____
Name

_____O'Brien Carr_____
Name