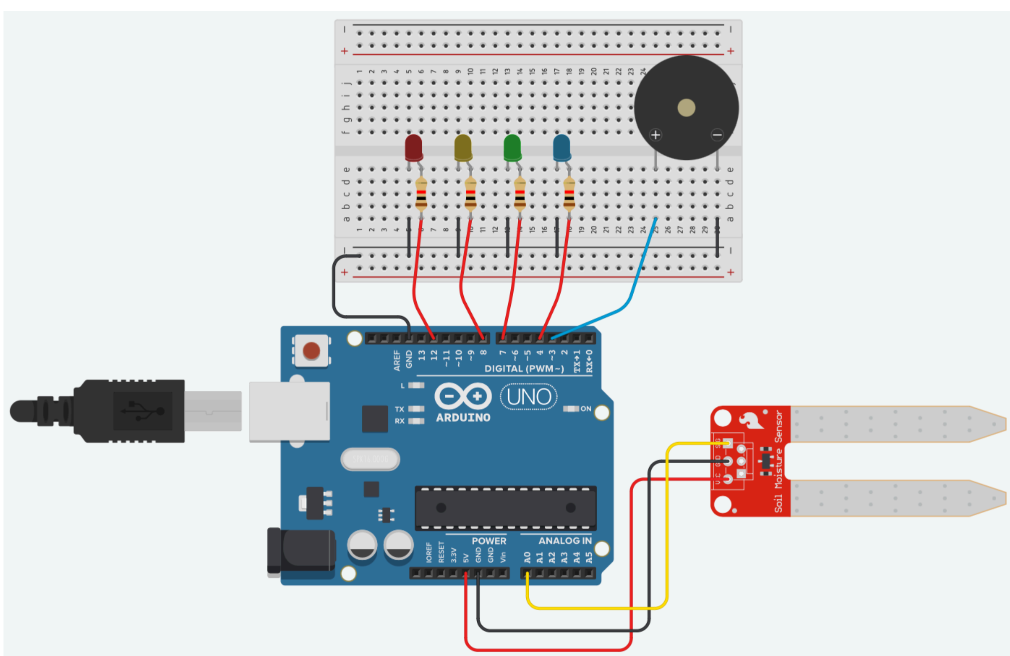
Soil Moisture Detector

Team members: Neil Patel, Eric Fontes, Joseph Mackle, Kacper Chojnowski, Eddy Chen, Simon Mejia

EGN2020C Spring 2023 Class # 21719 Dr. Andrea M. Goncher



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User Group and Needs Statement

User group: recreational gardeners

Our user group is recreational gardeners, normal people who practice horticulture within their homes. This can be anyone who grows herbs to use in cooking, those who grow fruit on trees, people who decorate their lawns with fancy arrays of plants, and anyone in between. However, our user group does not include industrial farmers or anyone who has access to expensive and large-scale equipment. The group hones in on those who practice small-scale agriculture and we hope to provide a solution that makes the process of gardening easier and more efficient. Gardeners face challenges in the gardening process such as pests, physical strain from outdoor work, sunburns, back pain, forgetting to water their plants, fertilizing their plants, and more. They would benefit from solutions that reduce effort needed to farm or products that automate part of the gardening process. With these factors in mind, we designed multiple products that would benefit the gardening community. Agriculture in the United States is a major industry, which is an important exporter of food. A 2017 census reveals that the US alone covers an area of about 900 million acres, averaging 441 acres per farm. In gardening, while modernized over time, there are still a lot of factors that prevent efficiency and safety for gardeners. Along with that, when creating our prototype designs, we considered the variety of plant, the right temperature for these plants, the desired moisture of different plants, and how often a plant would need to be watered. For that reason, we developed product designs that would specifically address said factors. Gardeners need products that make their work easier and more efficient, while also allowing for improvement and further satisfaction for the user. With these designs, which will include our final design decision, we hope to make an impact in the gardening community.

Expert Tip

If your product targets different customers, copy the template and do this exercise for each persona.

Get the full Conceptboard experience by inviting more participants to your board. Just send the URL to your teammates and start collaborating!

Recreational Gardeners Empathy Map

What are these person's Pains?

- Pests damaging crops
- Unpredictable and bad weather
- Forgetting to water plants
- Physical strain on body from working outside

What does the person Think & feel?

- Worry about the health of their plants
- Feel pride in their gardens
- Feel satisfaction with progress they've made

What does the person Hear?

- Other people may want to purchase their plants
- Social media influencers promote pictures of gardens
- Gardening tips from other gardeners

What does the person See?

- Gardeners observe the health of their plants
- Biodiversity of their garden
- They see animals and or pests in the garden
- Soil quality

What does the person Say & do?

- Sow seeds into soil
- Monitor plant growth
- Water plants
- Monitor plant growth
- Fertilize plants

What are the person's Gains?

- Crop yield
- Visual aesthetic of garden
- Healthy and organic food
- Biodiversity of garden

Sticky note stash

Sticky note stash

Design Justifications

Attributes	Attribute Weights	Masked Automated Irrigation System (out of 10)	Design A Weighted Score	Soil Water Level Detector (out of 10)	Design B Weighted Score
Environmental Impact	0.30	5	1.50	7	2.10
Effectiveness	0.30	9	2.70	6	1.80
Ease of Use	0.15	5	0.75	8	1.20
Low Cost	0.15	4	0.60	6	0.90
Safety	0.10	7	0.70	7	0.70
Total	1.00		6.25		6.70

In the end, we decided to create the "Soil Water Level Detector" to aid gardeners in the cultivation of their product as this solution scores highly in several key attributes. The "Soil Water Level Detector" had a weighted score of 6.70 which is 0.45 points higher than the "Masked Automated Irrigation System" score of 6.25. This is because to a prospective customer and gardener, environmental impact and effectiveness of the end product are the most important attributes as this user base cares for the environment and requires an efficient solution to make gardening easier. For reference, design A named the "Masked Automated Irrigation System" is a solution that automates the process of watering plants. In the category of Environmental Impact, Design B outperformed Design A because the reduced material needs of this solution means that the chances of harmful chemicals leaching into soil and causing damage are less than that of Design A. Although the Soil Water Level Detector underperformed in effectiveness (an automated irrigation system solves a bigger problem), it compensates by outperforming its competition in the rest of the categories. A device that measures soil water level is simpler to install and requires less materials to create than Design A, leading to higher attribute scores. Regarding safety, both apparatuses score similarly because an automated and remote device that plants itself into soil is inherently safe when it does not require human interference. When looking at the human-centered needs of the gardener, a few things come to mind. Solutions have to consider the variety of plant being grown, how often that plant would need to be cared for/watered, the ideal growing conditions of different plants, and the goal of improving overall gardening efficiency. Looking at the big picture, the "Soil Water Level Detector" fulfills the most user needs while being practical and scalable.

Ethical and Environmental Considerations

Ethical and environmental considerations were key factors in our prototype design. As a team, we understood the importance of ensuring that our product is designed in a manner that meets the needs of our user group (hobby gardeners), is inclusive, and has minimal impact on the environment. In terms of ethical considerations, the team took steps to create a product that could be used by all hobby gardeners, regardless of their physical abilities or limitations. To achieve this, we designed the Soil Moisture Detector to be easy to use, portable, and require minimal physical effort for those with limited mobility; the device is also incredibly lightweight, making it easy to handle and move around. The bright LED lights on the device clearly indicate when it's time to water plants, which makes it accessible to those with visual impairments. Our commitment to design for inclusion extends beyond our user group, as we recognized that our product will be used by a diverse range of individuals of all ages and abilities, including those who may not have any experience with gardening whatsoever.

Additionally, we made sure that the design is not only user-friendly, but also sustainable. The Soil Moisture Detector is made of durable and long-lasting materials, reducing the need for frequent replacements and therefore minimizing waste. We also made sure to use materials that are recyclable at the end of the product's life, further reducing its impact on the environment. In continuation, we designed the device to be repairable, with replacement parts available when needed. This eliminates the need to throw out the whole product and ensures that the device has a longer lifespan.

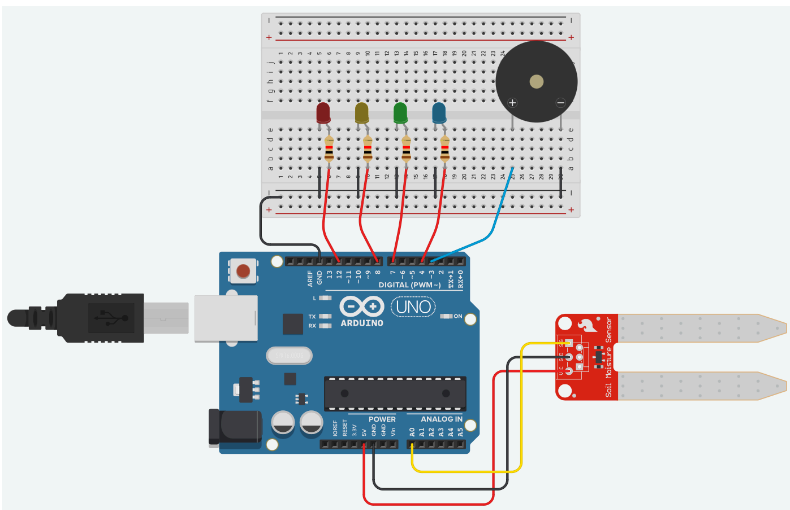
To conclude, our design team took ethical and environmental considerations seriously when creating the Soil Moisture Detector. We designed it to be inclusive, sustainable, and easy to use, ensuring that it meets the needs of our user group and others while having a very minimal impact on the environment. When considering the product's lifecycle, from development to disposal, we aimed to create a product that was not only practical but also environmentally and ethically responsible.

Tinkercad Electronics User Manual with List of Parts/Functions

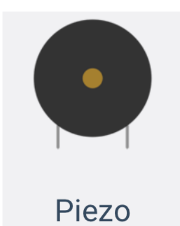
Steps for Use:

1. Ensure 9V battery is plugged in.
2. Put moisture sensor in ground near the plant you wish to test.
3. Read the LEDs. Red means the moisture level is below 25% and the plant must be watered. Yellow means the level is between 25% and 50% dry. Green means the level is between 50% and 75%. Blue means the level is above 75%.

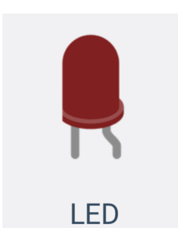
Circuit:



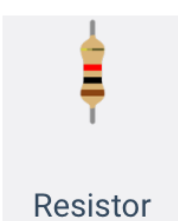
Parts:



<u>Piezo (actuator)</u>
Buzzes when moisture level is low or zero, lets the user know the plant needs water.

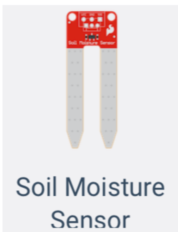


<u>LED (actuator)</u>
Four traffic light styled LEDs let the user know approximately what amount of moisture is in the soil. Red ≈ less than 25%, Yellow ≈ between 25% and 50%, Green ≈ between 50% and 75%, Blue ≈ 75% to 100% (too much water).

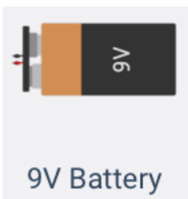


<u>1 KΩ Resistor</u>
Used for each of the four LEDs. The flow of electricity is resisted so the LEDs don't get damaged over time.

Arduino Uno
The brain behind everything. This reads the code and distributes the power to the correct LEDs / buzzer according to the readings taken from the sensor.



Soil Moisture Sensor (input)
This is the component that actually determines how moist the soil is.

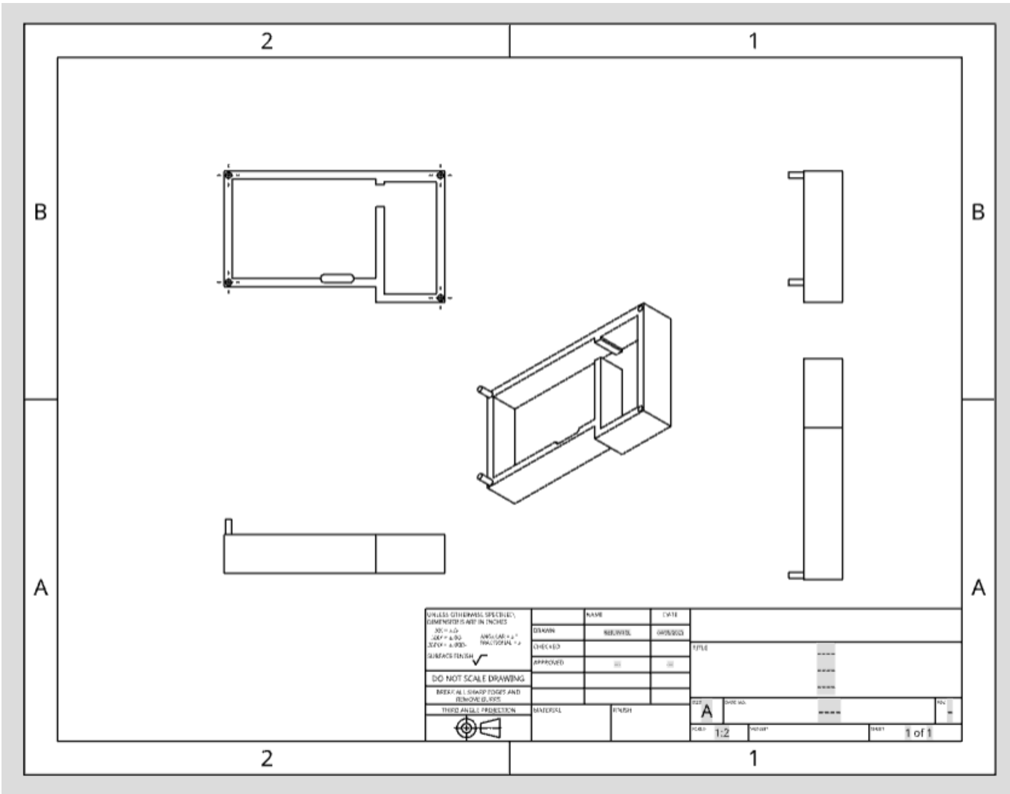


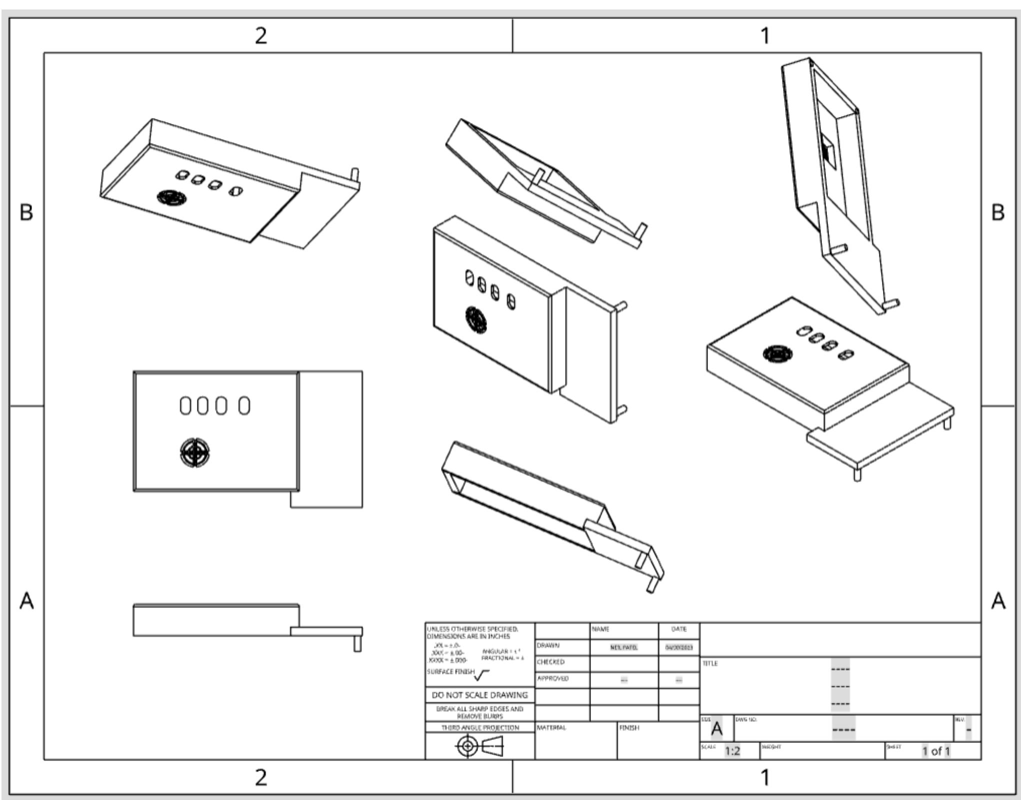
9 Volt Battery
The battery is used to power the device and its components without having to plug it into a wall.

Tutorial video link:

https://drive.google.com/file/d/15u04Wr01wl8GhX1dT3jumLa97DtiNuid/view?usp=share_link

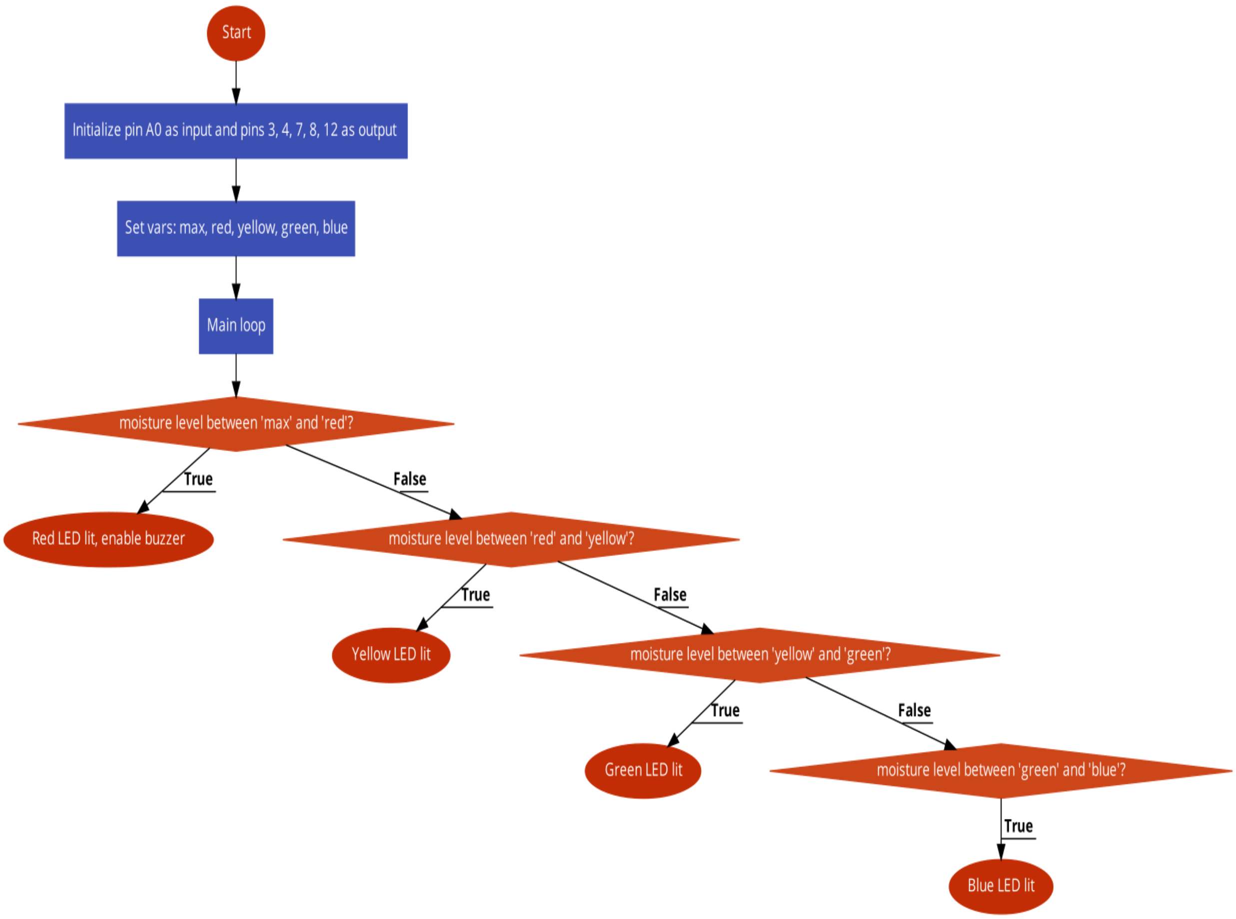
Engineering Drawings





There was more than one part in our final design of the Soil Moisture Detector. In the top drawing, the Arduino Uno rests in the main compartment and the 9 volt battery in the adjacent compartment. There is a small slit connecting them to attach the wire to the battery. On the second drawing, we can see that it has 4 holes for the 4 corresponding light bulbs and a designed cut out for the speaker system. Looking closer, there are 2 holes on each opposite side of each part and two coulombs on the other opposite side. This acts as the closing and opening system of the two parts. One challenge I had when designing this open/closing system was cutting everything in half and measuring everything halfway to make the soil moisture detector fit nice and snug. The second challenge I had was thinking and designing the most effective closing/opening system. There are many ways I could have gone about designing this, but the holes and columns were the easiest and effective.

Flowchart



Flowchart Description

This flowchart describes an ongoing loop for the four lights installed on the soil moisture detector. It uses true and false statements to determine what level of water is in the soil, which would be distinguishable by the output of whatever light would come on based on the soil moisture. It's designed like this for efficiency to see whenever the lights are out, the farmers, or gardeners will know to water the plants until they see all the lights come on the moisture detector. There is also a buzzer to indicate whenever the soil needs watering, so if the gardeners are busy doing something they will hear the ring go off and water immediately.

Commented Code

```
// C++ code
//
int max;
int red;
int yellow;
int green;
int blue;
float timer;
void buzz(float time);

void setup()
{
  pinMode(A0, INPUT);
  Serial.begin(9600);
  pinMode(12, OUTPUT);
  pinMode(8, OUTPUT);
  pinMode(7, OUTPUT);
  pinMode(4, OUTPUT);
  pinMode(3, OUTPUT);

  max = 1024; // maximum reading (in this case, 100% dry)
  red = 1000; // 75% dry
  yellow = 650; // 50% dry
  green = 400; // 25% dry
  blue = 0; // 0% dry

  timer = 0;
}

void loop()
{
  Serial.print(analogRead(A0));
  Serial.print("; ");
  Serial.println(timer);
```

```
  // RED light + buzzer
  if ((analogRead(A0) >= red) && (analogRead(A0) < max))
  {
    digitalWrite(12, HIGH);
    buzz(timer);
  }
  else digitalWrite(12, LOW);

  // YELLOW light
  if ((analogRead(A0) >= yellow) && (analogRead(A0) < red))
  {digitalWrite(8, HIGH);} else digitalWrite(8, LOW);

  // GREEN light
  if ((analogRead(A0) >= green) && (analogRead(A0) < yellow))
  {digitalWrite(7, HIGH);} else digitalWrite(7, LOW);

  // BLUE light
  if ((analogRead(A0) >= blue) && (analogRead(A0) < green))
  {digitalWrite(4, HIGH);} else digitalWrite(4, LOW);


  delay(10); // Delay a little bit to improve simulation performance
  buzz(0.0); // silences the buzzer if it wasn't previously silenced
  timer += 0.01; // increase timer by 0.01 (counts in seconds)
}

void buzz(float time)
{
  if (time > floor(time)+0.5) {
    tone(3, 100);
  } else noTone(3);
}
```

Design Limitations

In 300 words or more, reflect on your final prototype design, what went right, and what are your design limitations?

Everything on this project went as planned. When we needed to get something done the entire group was on board. The design was implemented perfectly, the code was executed flawlessly, the research was conducted accordingly, . All aspects of this project were carefully thought out and executed as intended.

How could it be improved to better fit the human- centered users' needs if given more money and/or time?

If the team was supplied with more money, there would be two things we would change. One, we would make the Soil Moisture Detector smaller in size, making it more portable and easier to use. Making the Soil Moisture Detector smaller would make the device less intrusive to the plants and won't affect the plants growth by blocking the plant's leaves and roots. Two, we would create an addition to the device being an iOS app. If a farmer owns more than one detector, the farmer can open the app and the app would tell the farmer which detector is going off and where it is going off. I would also say what light the detector is on so the farmer always has information. The app would be able to much more like keep the lights off to save battery, and the app would also send the farmer a notification if a crop is on a red light (dry).

Based on your initial testing of this prototype, what would you change and why?

Our final prototype design for the soil moisture detector was successful in achieving its purpose of alerting the user of the moisture of the soil that fits the plant. However, a limitation that we bumped into our design process was the size of the soil moisture detector. We would work a way to make use of a smaller battery and a smaller suricate board, then the design would have been more like an oval shape.

References

How soil moisture detectors help in maintaining farms smartly? An End-To-End IoT Solutions Provider. (n.d.). Retrieved April 29, 2023, from https://www.biz4intellia.com/blog/soil-moisture-detection-systems/

Sod Solutions. (n.d.). *How Can a Master Gardener Help with My Lawn and Garden?* Sod Solutions. Retrieved April 29, 2023, from https://sodsolutions.com/lawn-care-guides/how-can-a-master-gardener-help-with-my-lawn-and-garden/

White, T., & King, S. (2019, April 11). *2017 Census of Agriculture Data Now Available*. USDA. Retrieved April 29, 2023, from https://www.usda.gov/media/press-releases/2019/04/11/2017-census-agriculture-data-now-available

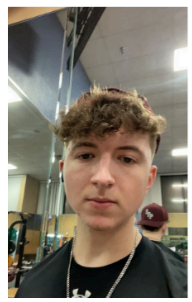
Appendices

Team Members


Eric Fontes


Joseph Mackle


Neil Patel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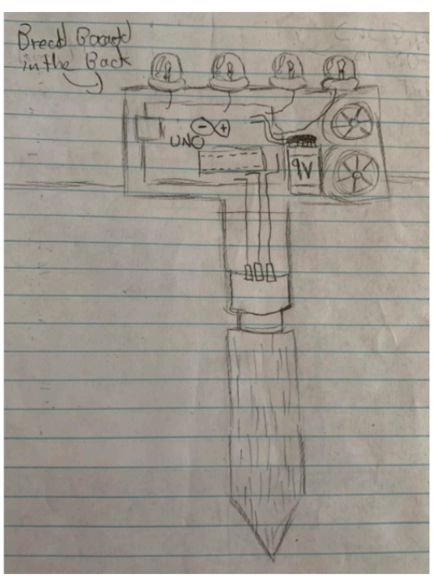
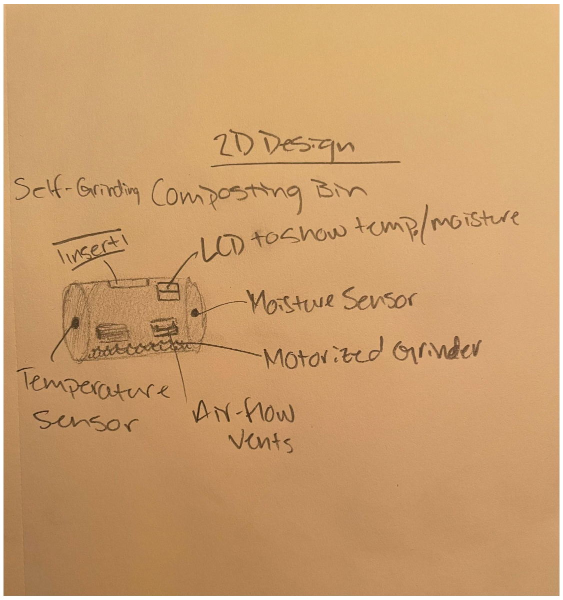
Original Prototype Sketch:



Other Prototype Sketches:



The arduino after we moved it onto a smaller breadboard: