Prototype 2: Build and Test

Test Purpose

In the original project plan, this test was intended to focus on prototyping the growing pipe, and ensuring that the system is able to hold water, however we switched the focus of the previous prototype and covered some of the objectives of prototype two. The last prototype was more comprehensive than intended, and now this prototype will focus on refining parts of prototype 1. The main objective of this test is de-risking aspects of our initial design. The main areas of risk that we discovered in our last prototype were potential leaks, and improperly integrating the filter system. We chose to refine these aspects because the seal of the system did not appear adequate, and there was also difficulty in attaching the filter system so that it would function properly with the rest of the project. After completing this prototype and test, our goal is to have our base hydroponics system complete and functioning, and to be able to focus on useful additions to the build in the next prototype

Test Objectives

The following are the specific test objectives:

1. Ensure a watertight seal at entry and exit points of the growing pipe when the system is filled with water.
2. Test flow controllability from the bucket to the pipe, and for no problem draining the pipe.
3. Ensure that the filter is able to remove most of the soap from a solution of shampoo and water.
4. Ensure that the water filter is able to clean water at a reasonably fast rate.
5. Ensure that filter does not allow particulate to enter the water bucket.
6. Bucket is able to support the filter system.

Learning Goals for Prototype Two

With this prototype, we are communicating the notion that our design generates and contains (without fail) purified water. We will learn if our prototype has any leaks as these would be a fatal flaw to our hydroponics design. With this prototype we will either learn that further steps must be taken to ensure no leaks, or we will communicate the notion that our design is effective at containing water. Furthermore, we will also design a filtration method to appropriately purify the inserted grey water. We will either communicate that this filtration method is effective, or learn that further steps must be taken to perfect this design.

Possible Results

There are four main results when analysing the design of this second prototype. The

prototype can be proven to fully contain the water, or leaks may be found. Furthermore, the filter can be proven to purify the water to an appropriate degree of effectiveness, or it can be considered to be too “grey”.

Action Plan for Results

If the results from these prototypes are successful, then it can be assumed that we will proceed with these designs. By successful, it is meant that this prototype both purifies the water and effectively contains it.

If the results from this prototype are unsuccessful (does not filter or contain effectively) then appropriate measures must be taken. By analyzing the results it can be determined what degree of modifications must be made. It may be found that the silicon used to prevent leaking was effective; however, one part of the PVC pipe was accidently missed. From this analysis it can be determined that the anti-leaking method is successful, and can be used to finish the prototype. If our design for a filtration system does not effectively purify the water, then analysis will be needed to determine how to proceed. It will be analyzed if the purifying medium (rocks) are unsuccessful, or if more are simply needed. If the rocks are an ineffective method of filtration then further concepts must be explored such as adding sand, or possibly designing a completely new filtration system.

Success and Failure Criteria

The criteria for test success or failure are based upon the 4 test objectives we set out to accomplish:

Objective	Specific objective	Criteria	Metric	Method of Testing
Water	Figure 1.0.1	No leaks at any point in the system	n/a	Visual test on prototype
Water	Figure 1.0.2	Water flow is controllable at both ends of the growing pipe	n/a	Experimental test of prototype.
Filter	Figure 1.0.3	Filter system can remove the majority of soap from a fake greywater	n/a	Visual test of prototype operation.

		solution		
Filter	Figure 1.0.4	Filter system allows water to flow through at an adequate rate	>1 LPM water flow	Measure
Filter	Figure 1.0.5	Filter system does not allow particulate to enter the water bucket.	n/a	Visual test of filtered water
Filter	Figure 1.0.6	Water bucket is able to support the weight of the final filter system.	n/a	Observation of the bucket system under a load.

When deciding success or failure of our design, we will use the criteria outlined above.

Prototype Scope

The prototyping type chosen to implement for the second prototype was a focused based one. For this prototype, we decided to go with the focused one, so that we would be able to test certain aspects of it that could potentially be an issue in our design. The two main attribute of our design we decided to focus on was the filtration system, and the materials used to prevent water leakage. We chose the focused type of prototype, so that we could ensure that the filter is effective in filtrating the grey water, and to make sure the water doesn't leak at all in the system.

Testing Process

Refer to the success and failure criteria table for the testing criteria that this testing process will be based upon.

The following is a step by step process of our testing plan:

1. Fill the system with water.
2. Observe the system to ensure that there are no leaking areas:
    a. Check the water entry point to the pipe
    b. Check the water exit point of the pipe
    c. Check the water exit point of the water bucket
    d. Check the area where the filter attaches to the water bucket
3. Test water controls to ensure water flow is able to be controlled by the used.
    a. Test water control into the pipe from the bucket
    b. Test water control for exiting the pipe.
4. Test the ability of the filter to clean water to an acceptable level and within an acceptable amount of time
    a. Fill the water bucket with water and move this water to another water vessel
    b. Add a bottle of shampoo to the water and mix it
    c. Place the water filter on top of the water bucket
    d. Dump the soap solution through the filter and start a timer
    e. When water is done flowing, stop the timer and record the time
    f. Observe the quality of the filtered water to see if any soap is remaining, and also if any particulate fell through the filter
        i. Feel the water
        ii. Smell the water
        iii. Look at the colour of the water
    g. Calculate the flow of water through the filter in LPM and check against the criteria

The following is an outline of our building plan:

Most of this prototype has already been built, however the following additions have been made:

1. Attach a piece of cloth at the end of the filter in order to block sand from entering the bucket
2. Apply silicone at any area that shows signs of leaking

Measurable Data to be Collected

Only one metric will be necessary for the testing the prototype. It will be required to observe and calculate the flow of water leaving the filter in litres per minute.

Observational Data to be Collected

Things to observe during testing are the following:

1. Observe all potential points of leaking in the system to check for leaks. This will be recorded by writing down observations of any leaks, or the lack of a leak at a potential leak point.
2. Ensure that the bucket is able to support the filled filter system. This will be recorded by writing down our observation of its success or failure.
3. The water will be observed after leaving the filter to ensure adequate quality. This is being recorded by writing down observations of water feel, smell, presence of any dirt/ particulate, and appearance.

Materials and Cost of Second Prototype

Most of the materials that are being used in this prototype, are being reused from the previous one. The only thing that is being added to this prototype is the silicon, so that water leakages can be prevented. Also, water with shampoo will be filtered through the system, so we can test to see if our filter works as it is supposed to. There will be no additional costs, as the materials needed are already in possession.

Work to be Done for Prototype Two

For this prototype, we will be adding silicon to wherever there are leaks in the system. Also, some rocks, sand, and a cloth will be used to test how well the filtration system works.

Test Results

For testing the prototype, the first thing that was done was, one gallon of water was flushed through the system to check for any leaks. We noticed, after timing the water flow, it took the one gallon of water 15 seconds to flow into the PVC pipe holding the plants, from the bucket. After the this test, we noticed that there was a leak in the tubing in figure 1. The leak was fixed by tightening the hose clamp on the tubes. We ran the water through the system again, after adjusting the hose clamp, and found that there were not any more leaks in the system. For the next test, we gathered a cloth, some sand, and some rocks to test the filter. To represent the grey water that the refugees

would be using, we mixed some shampoo into the water and drained it through the filter. After doing this, the water that was drained into the bucket through the filter was tasted by Graham, who says that the water didn't taste soapy. Also, it appeared clean, did not feel like there was any soap present in the water, however it did smell faintly of the soap used. Also, there was not any sand or rocks in the filtered water. After testing, the filter that was being held onto the bucket by silicone, broke off, so for our next prototype we are going to fix that issue.

Second Prototype

Figure 1: Filtration System

In this picture the filtration device for the hydroponics system is shown. This filtration device consists of a PVC pipe to contain the water, rocks and sand, a reused cloth, and plastic grated PVC endpiece. The plastic grated PVC endpiece is used to support the purification medium (rocks) from the bottom. A cloth is placed on top of the grated plastic, to prevent sand from entering the storage container. The PVC pipe is used to contain a large quantity of sand and rocks which slowly filter the grey water as it travels down the pipe. This pipe is placed vertically (perpendicular to the ground) and requires only gravity for water to travel through the filtration system.

These pictures outline the methods used to ensure the hydroponics system effectively contains the water. As it can be seen, 2 PVC end pieces were attached to both ends of the PVC growing trough. As can be seen in the top picture, with the PVC growing trough full of water, the end pieces are effective at containing this water. These end pieces are removable (with force), allowing the trough to be drained and cleaned if needed.

It can also be seen that leak sources were patched with construction grade silicon to ensure that the system contained all water. The silicon was applied on the inside of the bucket to ensure that water only travels through the piping, and does not leak out of the bucket. This same technique was used to secure the filter device to the top of the bucket Unfortunately, the silicone is not enough to hold the filter in place, and a new system will be implemented in the next prototype to address the issue.

Figure 2 : Leak Prevention

Refugee Feedback:

To ensure the highest level of quality in our design, we once again reached out to a former refugee by the name of Hasan Wiso. He was kind enough to give our group feedback about possible issues with our design.

In the first iteration of the prototype, Wiso commented on how some of the design aspects could become problematic for the refugee. One such example we examined was that structural integrity of the silicon. Wiso remarked about how it could falter due the severe wind in the desert regions. At high velocities, the shearing force of the wind

applied to the silicon may cause the silicon to lose structural integrity, possible cracking and dislocating the PVC piping from the filtration device. To account for this, the filtration system was tested by bringing the prototype to the Rideau Canal on March 11th 2017. The average wind in Jordan is approximately 17 mph, or 27.2 km/h, and the wind speed reported by weather.com on March 11th was 26km/h, within an acceptable test range. The prototype was laid outside for approximately 30 minutes, and then inspected. Upon examination of the bonds between the silicon and filtration bucket, and filtration bucket to PVC, some damage occurred and the filter did not remain entirely attached. We do have plans to fix this issue with the final prototype. Thus, silicon integrity for the winds of Jordan were marked to be unsuccessful for now, but the plan to solve this is already laid out

In the second iteration of the prototype, Wiso commented about possible areas of concern. Wiso mentioned that the leak testing may be an inaccurate representation of the breakdown over time, and as such while our testing may provide data on any immediate leakage problems, leaks could occur in the future. However, the time constraints of this deliverable paired with its costs make testing for the longevity of the system unrealistic, and therefore were not tested in this deliverable. As this iteration is a more concentrated version of the prototype testing, many of the concerns are reiterated from feedback received from the first prototype. These include the degrading nature of paper cups and the water stagnation in pipes, which will be addressed in prototype three.