TeSi Team 3 Final Report

Things left to do for the report

- ☐ GULP research summary
- ☐ GULP Interview
- ☐ Whole Solution Section (including prototype)- done with writing, just need pics
- ☐ Images for entire document (mindmaps, whiteboard, prototypes)
- ☐ Rearranging section 2 to prevent overlaps (will do after GULP research is completed)

1. Introduction

The technology we are working with is a type of glass that is formed through polymers. Indeed, the company Glassomer has developed a way to create glass that is highly customizable and has an accuracy of half a millimeter, which is much better than standard glass, and is not the case for alternative methods. Furthermore, the company can do so at a cost and speed similar to that of high performance plastic, which overcomes a significant barrier associated with the current production of glass, and also has a lower environmental impact than plastic. In short, this technology could be described simply as a highly customizable and precise glass with the production benefits of plastic, as it is both cost and time efficient.

The creation of this glass goes through a continuous process. The first step of the process is pouring the polymer (plastic) and the glass solution in its desired form into a 3D printer. Then, the printer produces a “green” object, which is made of a substance that has plastic and glass particles. Next, the “green” form is heated in a ceramic oven to extract the plastic from the mold and give way to a chalk-like form called the “brown” part. Finally, this “brown” part is heated at 1650ºC to obtain the desired shape made of fused silica, revealing a shrunken version of the initial customized object. The process is cyclical because the polymers used for one piece can be reused for another piece, so there is very little waste material being produced.

The manufacturing process first appeared to be slow, but has been sped up by using Powder injection molding, which is energy efficient and environmentally friendly. This solution gives way to many applications such as fiber optics material, precision watch components, etc., since it can minimize production time and cost to levels similar to plastic. In other words, by making fused silica a more accessible product, existing products using glass can become cheaper or products using plastic components may be replaced with fused silica.

2. Research

a. Exploration of potential applications

When we first began brainstorming different applications of Glassomer's technology, we produced several ideas that we felt confident in pursuing further. The main ideas we came up with were: silica glass packaging, production of glass art, personal security, solar panels, and finally water sanitation.

Silica Glass Packaging

The first of these ideas concerned glass packaging. Understandably, plastic and cardboard are used for packaging in most cases. Glass would be impractical to use as a package for commonplace items such as groceries because it is heavy and prone to breaking. However, there are certain industries that utilize glass packaging for the sake of aesthetics and elegance, such as perfume brands. For this reason, using glass packaging for more expensive items would make sense. Items that are delicate, small, or often given as a gift would be a perfect item to encase in glass for the purpose of making the moment more impactful. Creating custom packages for special occasions could be a niche market we can target with this technology.

To explore this potential application, we emailed several employees at high-end businesses so we could interview them, whilst at the same time theorizing how the glass packaging could work and mapping out the process this product would follow, from production to end-user delivery. This revealed to us the main flaw in this idea, which was the distribution of the glass packaging. We asked ourselves how the packaging could get to the retail stores without breaking and how many of these "packages" we could send to a store in comparison to customized cardboard boxes, which made it abundantly clear that it was not going to be cost-efficient enough for it to be viable, so we decided to stop pursuing this idea.

Production of glass art

Glassomer technology could also be used for the purpose of art. Glass has been a medium for art for hundreds of years, and this technology could bolster it even further. Specifically, glass etching and drawings could be made with more detail and precision than they are now, as Glassomer's technology is known for these qualities. Alongside precision glass etching and drawing, glass could be used as a medium for fashion designers. As artists who are constantly searching for new materials, inspirations, and looks, fashion designers could interweave glass with other fabrics or simply make garments made entirely of glass.

However, throughout the process, we learned through interviews with glass artists that their work is incredibly difficult to replicate, so much so that none of them had even considered making replicas. Therefore, we shifted from presenting Glassomer's product as a new and better medium of expression for fashion designers to a product that could help glass artists replicate their work quickly and cheaply to sell. With this renewed focus, we proceeded to continue researching the viability and feasibility of this idea.

Personal security

Personal security is also a field that could benefit from Glassomer technology. The idea behind this utilization is that the fragility of glass does not always have to be its weak point. By using glass for personal security measures, our group decided that breaking the glass could be the intent behind the design. For this idea, we could find a niche market among deaf people. Deaf people cannot hear alarms when they go off in their schools, homes, etc. Therefore, they would need some sort of visual or tactile queue to make the emergency evident. This idea combines both. It is well known that glass shatters at a certain frequency. We thought that a glass bracelet or garment can identify when an alarm is going off and emit a high frequency of its own that would crack the glass. The user would feel or see the glass crack and realize there is an emergency and that they are in danger.

We proceeded to research this idea because we believed in its potential to help a group of people who are generally not thought of when designing day-to-day procedures. However, after interviewing a deaf Instagram influencer (and being ignored by several others), it became clear that the "problem" we thought was worth solving does not really exist. In other words, this solution was not desirable.

Solar panels

We also explored the possibility of applying Glassomer's technology to solar panels. This is because fused silica is much more transmissible of sunlight than regular glass, so we believed that it could help increase the efficiency of commercial solar panels. In theory, this would make solar panels more popular because of their improved performance. However, we decided to stop pursuing this idea because information regarding the challenges involved with the production and selling of solar panels was hard to come by. Additionally, companies were hesitant to help us because the information we were asking for was patented.

Water sanitation

Our final idea, and the one we decided to base our project around and create a prototype for, we call Project GULP. After considering issues that have a great social impact, we found ourselves constantly coming back to the severe lack of clean drinking water in an abundance of places around the world. We brainstormed several different options in combating this issue, but eventually settled on creating a water treatment system that utilizes UVC light to detect and kill bacteria often found in drinking water. With more research, we learned that fused silica glass, which Glassomer creates, has a higher UV light transmission (84%) than the current glass used in UV water treatment systems (60-80%). Furthermore, once we had the technology figured out, we realized that we could shift Glassomer's current business model to a razor and blade model, in which Glassomer would provide their technology and product to both NGOs and direct users, creating a constant loop between all three parties that provides consistent income. As we developed this concept further, continuous research gave us enough confidence and insight to move forward with Project GULP.

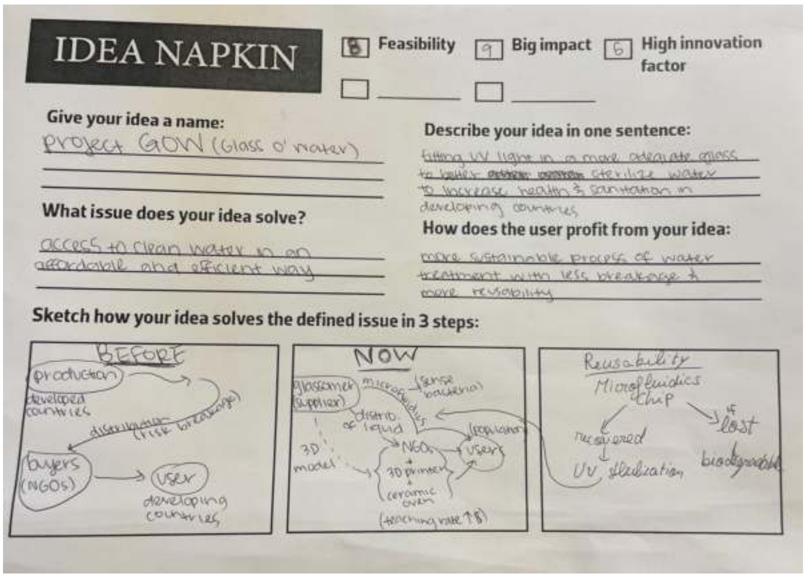


Figure 1: "Idea Napkin" showing the basic concept of project GULP (formerly known as GOW)

b. Further refinement of project scope

Project GULP

After careful consideration and name change, we decided to take on project GULP (Glass UV Light Purification) as our main pursuit. Indeed, we find that the competitive advantage of Glassomer can be taken to new heights with this socially impactful business model, mainly because of the omnipresence of the root problem it could aid in solving.

To further clarify on how UV light water treatment can be used alongside Glassomer's technology, it is important to mention that fused silica, the final material obtained after the last heating process, is among the highest in terms of UVC transmissibility. Since the production of fused silica glass is more costly and time consuming than normal glass, Glassomer would be providing a solution that can improve the efficiency of current UV water treatment systems. In addition to this, Glassomer can also produce a type of microfluidics chip that makes it possible to detect bacteria. Furthermore, this product is already made by Microfluidics chip shop, the company which Glassomer collaborates with.

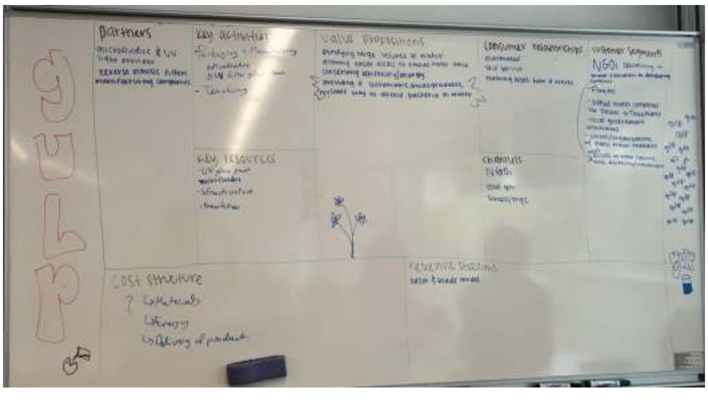


Figure 2: Project GULP's Business Model Canvas

Project Glass Mania

The first idea we named Glass Mania, and involved introducing glass artists to Glassomer's technology to provide a method for duplicating their pieces in a much faster and cheaper fashion. With Glassmania, glass artists could automatically produce multiple copies of their original pieces, similar to painters creating prints. Rather than taking several months to design and create each individual piece, glass artists could produce one original piece, send a 3D render to Glassomer, and receive as many exact replicas of their art as they want.

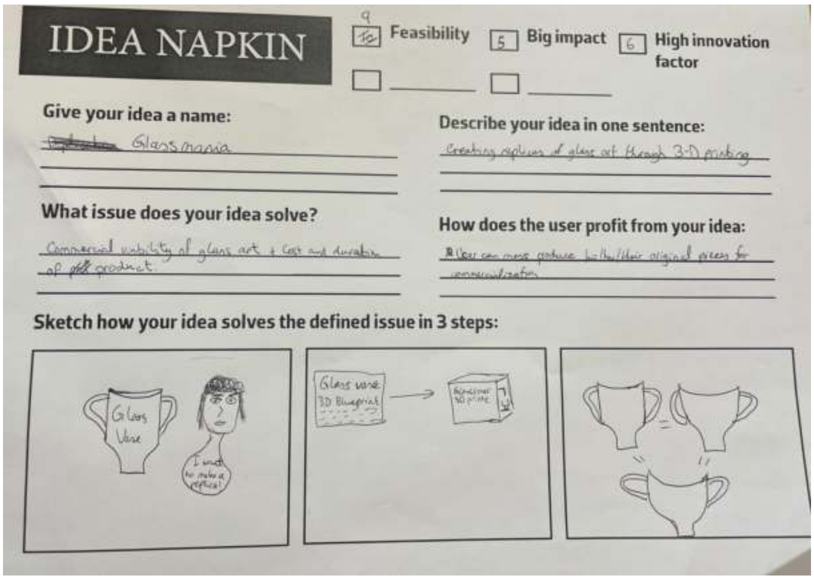


Figure 3: "Idea Napkin" showing the basic concept behind project Glass Mania

We refined the concept of Glass Mania by mapping it on the business model canvas. Here, we were able to define who our customer segments were and choose which one was worth pursuing the most. In the end, we chose to focus on younger glass and ceramic artists, including 3D designers, who would be more open to new technology for further self expression, and on a more practical note, interested in capitalizing on the cost reduction and quicker reproduction times that Glassomer's technology offers.

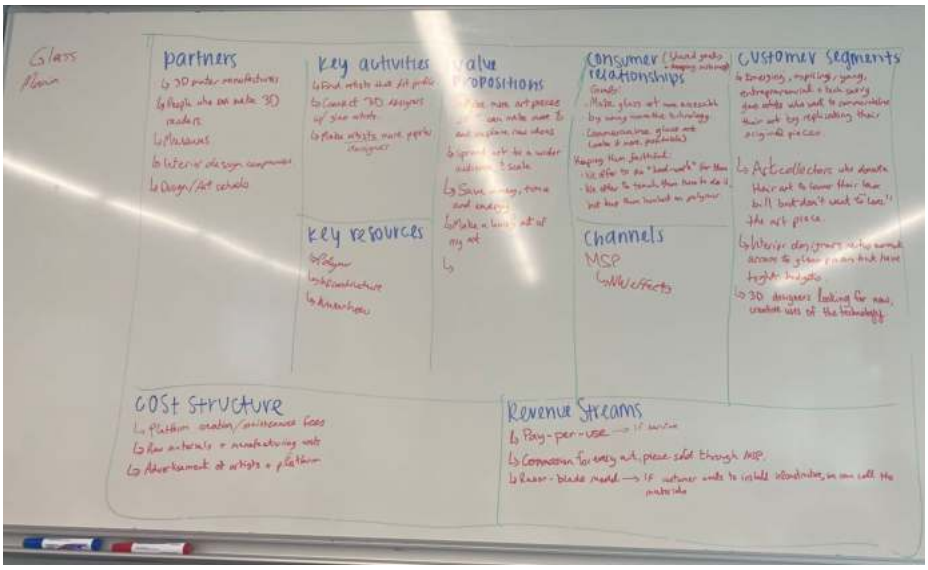


Figure 4: Project Glass Mania's Business Model Canvas

Sadly, it was pointed out that following this project would result in a service with a hard-to-measure social impact. Sure, we could argue that making art more accessible is a noble feat, but when it comes to how transformative it can be from a macro perspective, the reality is that this project will change the lives of a very minimal portion of the population. Additionally, as a team we had trouble framing this product as a service and describing exactly what that would entail. The original idea was to connect with glass artists and provide custom glass designs using Glassomer technology. Throughout the course of the project the business model transformed into an opportunity for these glass artists to commercialize and mass produce one of their works without having to go through the tedious and long process of reproducing their work by hand. Contacting professional glass artists such as Susan Bloch gave us helpful insight in terms of the desirability of a service like this. She had not heard of any way to replicate a piece exactly but did guess (without our assistance) that 3D technology might be useful in this regard. However, she had reservations about how many artists would actually want to use this and whether it would be helpful or destructive for the glass art community. Glass mania at its core is a great idea, but leaves many questions to chance when determining the desirability and viability of this service as a whole. Thus, we decided to invest the remaining time on filling the gaps on project GULP as much as possible so we can present a valuable solution to a more pressing social need, like access to clean water.

<u>Solaglass</u>

Our other idea we referred to as Solaglass, and consisted of curved solar panels to take full advantage of the sun's energy. Current solar panels are inefficient in their structure, as the flatness does not receive direct maximum exposure to the sun. We believe that since the sun is constantly moving across the sky in a circular motion, solar panels should imitate this movement by having a rounded shape. This way, no matter what time of the day it is, the solar panels would be absorbing the maximum amount of solar energy possible. After we investigated further, we had trouble learning exactly how this would work, as well as which way the curve should be structured. While we were confident in Solaglass' potential for influence, we lacked knowledge and research to understand this project's feasibility.

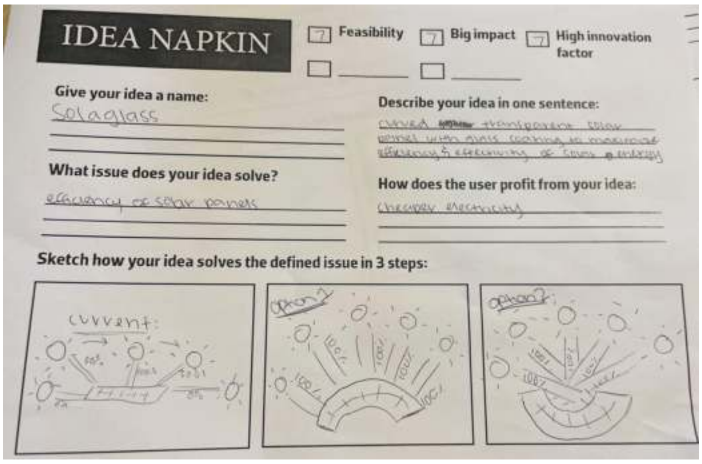


Figure 4: "Idea Napkin" showing concept behind Solaglass

c. Summary of further research conducted

Glass Mania

At the end of the first week, we sent out around seven emails to artists and manufacturers in the glass industry to gain better insight about their experience and challenges in their line of work. Because we wanted to take advantage of Glassomer's ability to achieve high precision, durable and clear glass, we made sure to reach out to a variety of professionals who had different areas of expertise, such as silica glass artists Susan Bloch from Guild of Glass Engravers, Anna Alsina Bardagí, a contemporary glass sculptor, and Roberto Perez Castro from SCHOTT, who is the managing director of the glass manufacturing company.

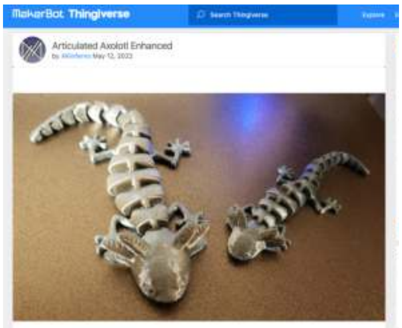
In our first interview with Anna Bardagí, we learned how her specialization in Casting consists of numerous steps involving prototyping, modeling, cooking, cooling down and polishing, all of which can cost up to 1500 euros for the entire process. Because of this high cost of producing one art piece, she explained that she is unable to commercialize and sell art pieces for a living, and instead is left doing alternative jobs unrelated to art. Exact replication of her artworks were also mentioned to be very difficult, given that the creation process is extremely laborious and unique.

Another interview we had was with Susan Bloch, a glass engraving artist from the Guild of Glass engravers. The process of her glass creations were similar to what Anna had previously mentioned, except that her engraving would take up to 4 days to refine one small work. Most of her work was described to be "one of a kind", and she revealed that she would like to explore different concepts and designs if not for the long process of creating a singular work. When asked about the possibility of creating "prints" of her work, similar to what 2D artists do, she mentioned that she was not aware of any available technology or method that would make this possible for 3D works, although she was intrigued by the possibility.

Through these interviews, our most valuable insight was the challenges of creating and manufacturing glass works. Not only did all interviewees mention the high costs and long duration, but a few artists also mentioned that although each piece created is unique, the production process makes it almost impossible to achieve the same results again. Bloch also stated that there was no available technology or means for artists to make “prints” of their work, similar to how 2D artists would commercialize their work.

Of all the glass artists we interviewed, they also mentioned that SCHOTT manufacturing was one of their main sources of obtaining materials. After conducting further research into the company, we also reached out to SCHOTT’s managing director, Roberto Perez Castro, to learn more about their manufacturing and supplying process. The conversation we had with Castro was different from the artists as we asked more questions related to the technical business model in order to understand the process and associated challenges in the glass manufacturing industry. During our conversation with Castro, he described the business model and manufacturing process of his works, as well as the versatility and adaptability of the technology they use. While SCHOTT has never engaged with artists to produce glass works, their business model is adaptable to cater to the requests of these clients in the same manner as others.

Based on these insights from the interview, we then identified the commercial viability and challenging manufacturing process as our area of focus and then refined the concept through prototyping. We had the opportunity to use CERN’s 3D Printing technology where we found a sample artwork to replicate for our prototype.



Sourcing sample artwork prototype on Thingiverse.com

Uploading digital file onto 3D Printer

Final prototype and replicas made of the original artwork

<u>Project GULP</u>

To further develop our final project viability, we analyzed domestic versus industrial-municipal uses, light manipulation tactics, cost comparisons, challenges, glass types and durability.

We found out that Industrial - Municipal UV sterilization methods have more benefits, but at higher cost and require more time to build (see Appendix for Table comparison and reference images). Therefore, given the fact that Industrial - Municipal UV treatment methods require big investments and large-scale glass casings, we determined that Glassomer’s current production capabilities were not suited to this level of water treatment, so we pivoted to focusing more on UV water treatment at the domestic level.

Whilst looking into the advantages of fused silica over existing alternatives, we learned that the glass casing used in domestic UV water treatment systems requires replacement at least once a year because of wear and tear. With Glassomer's product, this problem could be minimized because of its greater efficiency at transmitting UV radiation, thus being less affected by wear and tear over time.

The second week of the program, at CERN IdeaSquare we corroborated our ideas with the help of scientists, Pablo in particular, who suggested we look into irrigation systems such as drip irrigation, as it is currently made of plastic and could be an innovative and sustainable application of the glass technology. During our research in drip irrigation, we determined it could not be a feasible idea since we would not be able to bend this type of glass. However, we did find out that our project could involve cleaning contaminated water. As we pursued this finding, Pablo introduced us to using microfluidics to test and sterilize contaminated water in developing countries. Based on the research we did on microfluidics, our idea started to take shape and led us to investigate in detail UV light transmissibility, bacterias, harmful chemicals and how a microfluidic chip would work in the water treatment process.

Regarding light manipulation, we learned that different types of glass have varying transmissibility factors. In other words, not all glass lets light through in the same way. This became one of the pillars of GULP's value proposition, since fused silica is one of the types of glass that allows the most light through. Therefore, we could improve current UV water treatment systems by simply replacing the glass sleeve that covers the UV lamps. To demonstrate this, we found a graph from an experiment made by a fused quartz and fused silica manufacturer that compared the transmission curves of different types of glass.

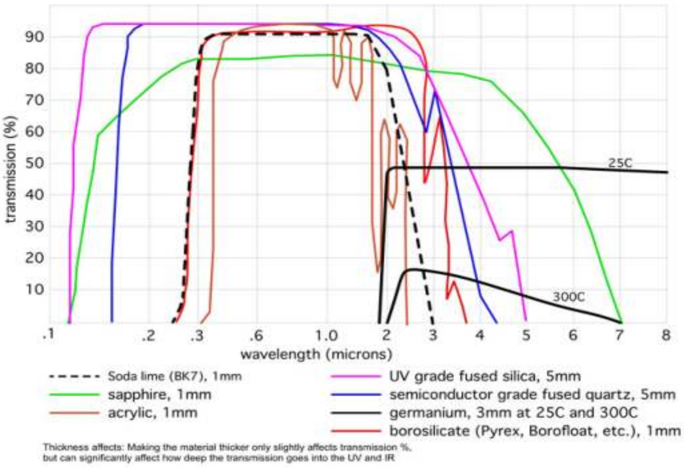


Figure 5: Graph showing the transmissibility of different types of glass

Here, we can see that UV grade fused silica, with a thickness of 5mm, transmits more than 90% of UV light, which is in the range of 0.01 to 0.38 microns. It became evident that Glassomer's product can make current UV systems better by increasing the efficiency of the UV radiation due to the sufficient transmissibility of fused silica.

The third week, at FabLab, we designed and started building our prototype with the help of Matthieu, the FabLab Founder at Esade St. Cugat and an expert in digital fabrication and 3D printing. He introduced us to different softwares such as MakeCode Microbit, to learn about coding using physical electronic devices, InkSpace, to design boxes using laser cut technology and Tinkercad, to get us started in designing objects for 3D printing. After learning about each software technology, we agreed on developing our prototype based on the following methods: laser cutting, electronics and 3d printing.

Finally, we set up an interview with Dr.Willox, a professor from UCF, who has expertise in sustainability to give us advice and offer suggestions for future improvements. These are the highlights extracted from the interview about our project……..***ADD INTERVIEW***

3. Solution

a. Overview

After researching various structures and methods of water treatment systems, we eventually concluded on one specific design that consists of two sediment filters, a UVC lamp, two microfluidic chips, and a water pump. The dirty water is first circulated through the water pump and through the two sediment filters before reaching the first microfluidic chip, which detects whether or not it is clean water. Then, the water continues through the UVC lamp, killing bacteria, and then reaches the second microfluidic chip, which confirms that the water is now clean and drinkable. The structure of our water treatment system is simple yet efficient, and allows for easier installation and maintenance.

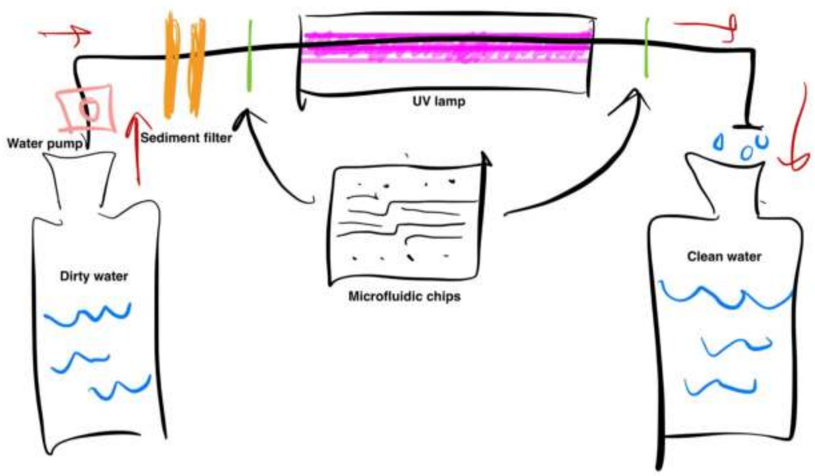


Figure 6: Diagram of Project GULP prototype

b. Prototype

<u>Microfluidics</u>

Microfluidics is defined as the behavior, precise control and manipulation of fluids. In water treatment, microfluidic chips can be used to detect harmful chemicals or bacteria. In our water treatment system, the microfluidic chips would be filled with specific antibodies that react to various bacteria in contaminated water. If these bacteria are detected, the microfluidic chips will change color to alert the user of contamination. After the water passes through the UVC lamp, it will continue through a second microfluidic chip filled with the same antibodies, that tells the user if the water is decontaminated by either changing color (still dirty) or remaining the same (clean water).

In our prototype, we began by using MakeCode by Microbit to code sensors that display either “dirty water” or “clean water” depending on the color and light exposure of the sensor. This sensor closely reflects the actions of the microfluidic chips that would be in our product. Additionally, we had to code an electronic water pump to push the water through the system. Using Microbit, we created a code that, when activated, starts the electronic pump, thus pushing the water through the first sediment filter, and gives it enough force to continue through the entire treatment system.

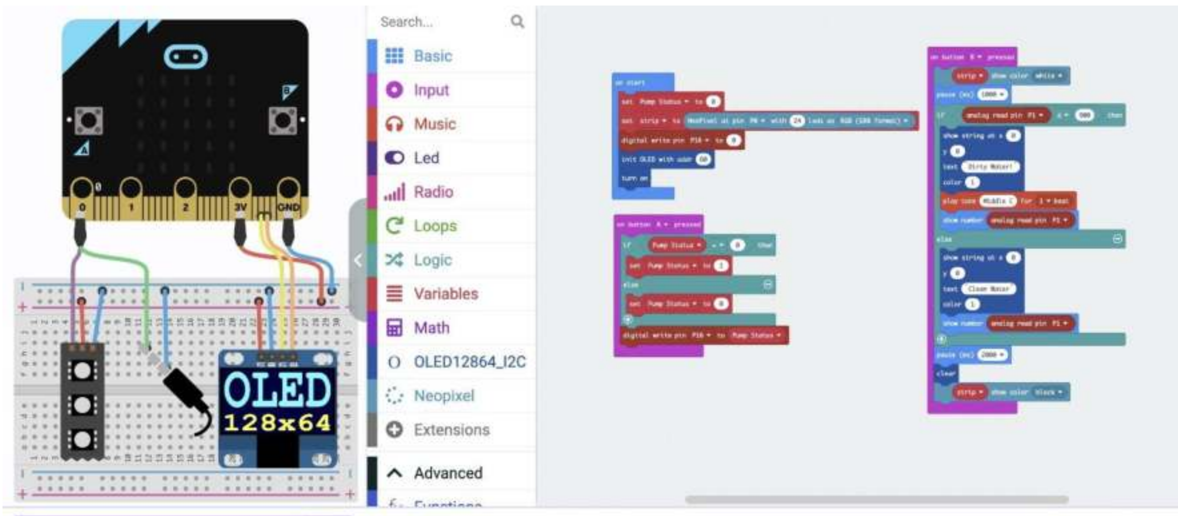


Figure 7: Image of the code used to install electronics in prototype

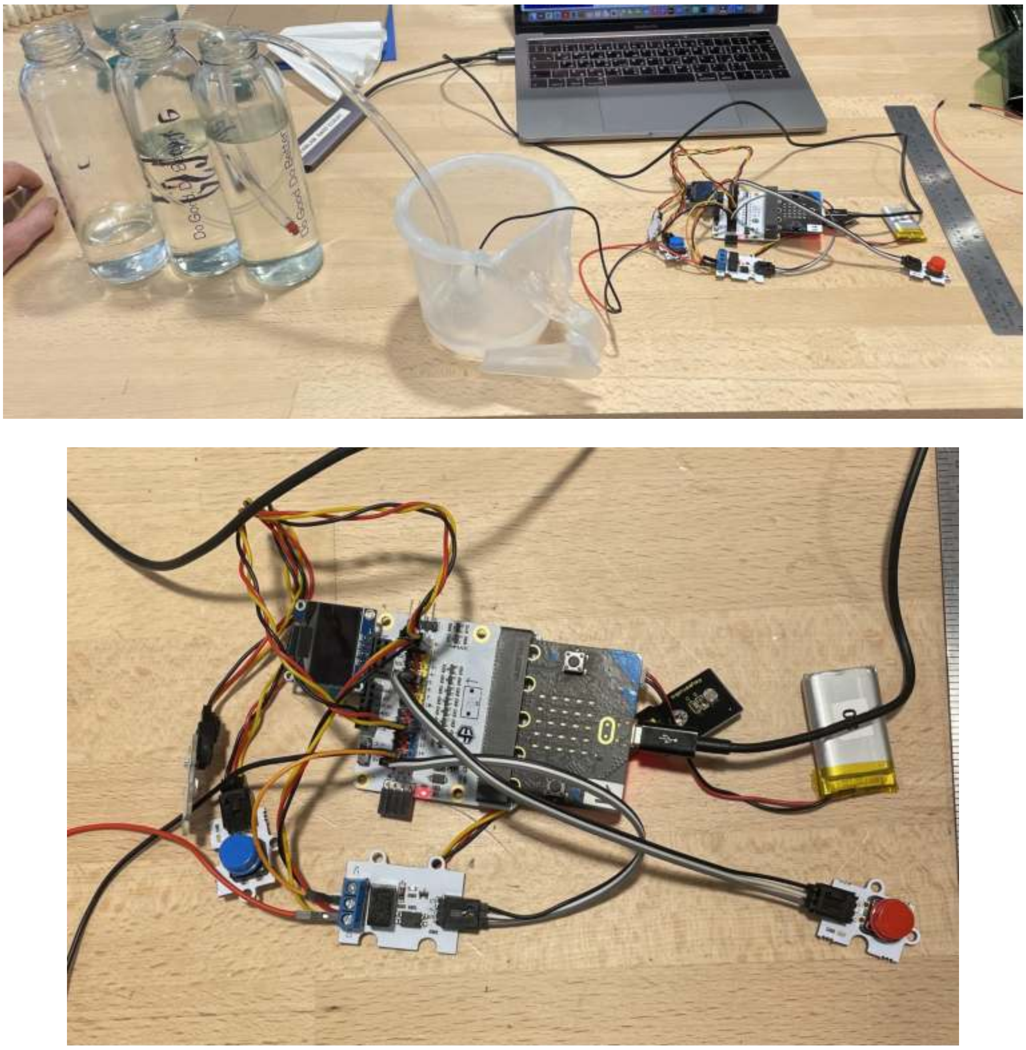


Figure 7 & 8: Pictures of electronics used in prototype

<u>Bottles and Filters</u>

To display how the water runs through the whole system, we used three water bottles to separate the three parts of treatment: the sediment filtering, the first microfluidic chip before the UVC light, and the second microfluidic chip that makes sure the water is decontaminated. Because of the tubes that had the go in the bottles for the water to run through, we needed bottle caps with holes that would hold up the water bottles while also weaving the tubes through the bottles. So, we designed and 3D-printed three identical bottle caps with the same dimensions as the bottles' original caps, and added two holes in each for the tubes to run through. We also used coffee filters in the first bottle to represent the sediment filters that the water runs through prior to the microfluidic chips.

Figure 9: Bottles used for prototype

UV Lamp

The most defining trait of our water treatment system is the UVC lamp itself, which is unique from other water filters in its ability to detect and kill harmful bacteria that causes diseases such as e. Coli, typhoid fever, salmonella and malaria. To demonstrate this component in our prototype, we used batteries, blue lights and a simple switch. The batteries are wrapped in blue lights to imitate a UV lamp, and positioned horizontally along the filter to indicate the movement of water through the system. We also coded a Microbit to serve as a simple switch that acts as an on-and-off button for the lamp.

Box Covering

The last component of our prototype is the box, which covers the entire system and protects it from any detrimental outside forces. It also benefits the product aesthetically, making it look much cleaner and hiding all of the wires. To make this box, we designed and laser-cut a wooden structure with three holes for water bottles and three holes for microfluidic chips, as well as a spot for the sensor display. Although there are only two microfluidic chips in the system, the third hole is used to take the chips out of their original place and put them in front of the sensor, which then displays the status of the water on a small screen. Ideally, the final product would not include this extra step, and would instead automatically sense the bacteria found by the microchips without any added movement.

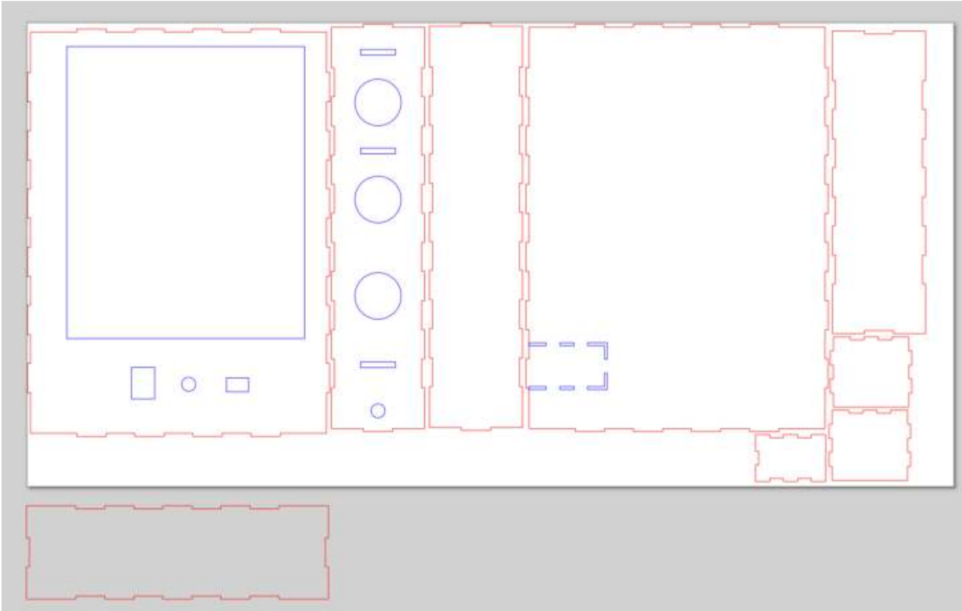
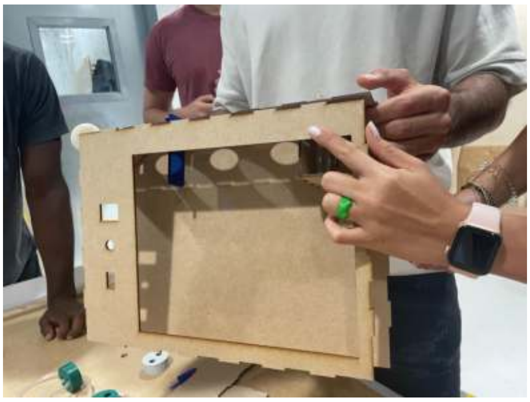


Figure 11: Box mockup in Inkscape



Final Solution: (PHOTO or DRAWING of PROTOTYPE)

4. Further extensions

Although we are confident in the feasibility, viability, and some level of desirability of the product we are offering, there are still some questions that remain surrounding the UV light purification system. Currently, our project focuses on the sanitation of water. However, a future possibility for Glassomer would be to expand their scope to produce both the filtration and sanitation of water. As water filtration and sanitation are both essential steps in making water drinkable, integrating the filtration step into the sanitation step would allow for greater efficiency and impact. Another question that arose about GULP is whether it would become possible for this Glassomer product to expand beyond a domestic level. Initially, we made it a priority for this product to be personally accessible and usable for individuals and family units. However, it is worth noting that this product has the potential to be scaled for much more widespread use. Project GULP began with the possibility of providing microfluidics and UV lights to users in developing countries through NGOs for the purpose of purifying bodies of water. If applied and used correctly, this technology could drastically change communities affected by contaminated or dirty water. While seemingly a great idea, the viability of the business model using this channel was highly questionable and we determined that to launch this product, accessibility and usability for the individual should be first priority. However, if established effectively at the household level, this product clearly holds potential to be impactful on a national level.

Alongside the questions we have concerning the potential of GULP, we have also discovered some risks associated with the development of this product. The most obvious risk resides in the property of the glass itself as it is a very brittle substance that is prone to break. The likelihood of the glass breaking is highly dependent on the type of glass, thickness, and force applied to it. Like any glass, being careful in its handling will minimize this risk considerably, but current domestic UV treatment systems already consider this variable. Therefore, even though we recognise the risk that the glass might break, we do not believe it is a major concern. Another risk of this product is that we can only control the purification process and not the filtration. When producing drinkable water, the water must first go through a filtration system in which sediments and large particles are removed from the water. It is only after this filtration process that the purification of the water can happen by killing or sterilizing harmful bacteria that remains. However, in our product GULP we are only providing a purification system and frankly have no control over the filtration system consumers might use beforehand. Without an effective filtration system, the purification process is useless and the water may not be drinkable. This presents a risk as we simply do not know the quality of the filtration being used and is also the reason we had the idea to produce the filtration system with our product. The filtration of the water also proposes a separate risk in terms of the effectiveness of the UV. Even if the system is able to filter sediments and large particles, the UV light will not be effective if the water is murky. Once more, issues with the filtration system and quality of the water are out of the control of us and our product and as a result this can pose a serious risk to the effectiveness of GULP.

5. Appendices

Type	Price tag (USD)	Installation Cost Range (USD)	Labor (hours)	Annual cost (USD)	Total Average Cost (First Year / USD)
Whole House UV	200-1000+	100-500	2-4	120	420-1620+
Single-Point UV	70-200	100-300	1-3	80	250-580

Model 500 Uv Filter System

MODEL 500 **Price: $245**
120 AC UV Water Purifiers
More information about this System
MODEL 512 **Price: $245**
12V DC UV Water Purifiers
Usually Ships in One Week

Choose Power Source

12V DC (Model 512)

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