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A concrete water pasteurization device For third world countries

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A Concrete Water Pasteurization Device

For Third World Countries

An Honors Program Project Presented to

the Faculty of the Undergraduate

College of Visual and Performing Arts

James Madison University

In Partial Fulfillment of the Requirements

for the Degree of Bachelor of Science

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by Andrea Rose Murchie

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Accepted by the faculty of the School of Art, Design and Art History, James Madison University, in partial fulfillment of the requirements for the Honors Program.

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PUBLIC PRESENTATION

This work is accepted for presentation, in part or in full, at a Duke Hall exhibition space on March 26, 2016.

DEDICATION

I would like to dedicate this project to all of the people in the world that are still without sustainable access to clean water.

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PREFACE

I was inspired to develop this project during Honors Seminar study abroad course in South Africa. South Africa is very close to my heart as it is where my mother and her whole family were born. When I was in South Africa with JMU we visited Edendale Hospital in Edendale, KwaZulu-Natal. On our visit, we brought toys and games to play with the children in the hospital who were able to be up moving around and for the children that were bed ridden. After talking to a nurse who was caring for some of the children I learned that so many of the children were there as burn victims. The main causes of the burn accidents were from the open cook fire in their home, as children are often the ones to tend to a cook fire, or from spilled boiling water that was being sterilized to make it safe for drinking. Many of the children lived in rural areas as well and had to travel long distances to get to this hospital despite it being the closest one to their homes. Learning this and spending time with those children was a very moving experience for me.

During my first semester back at JMU after this trip, I had the opportunity to consult on an Engineering Capstone project focused on the development of a 3D concrete printer. This is a technology that has promising future applications. There are only a handful of 3D concrete printers that exist in the world today. Every day there are more people building them and more people working on advancing the technology's capabilities. 3D concrete printing technology suggests a new way of conceiving of fabrication processes for designed objects and products; despite being in a phase of research and development, it is something that contributed to the inspiration for my project as well.

When the time came to develop an idea for my Senior Honors Project I wanted to tie together my experience during my Honors Seminar class in South Africa and the technology of the 3D concrete printer. I chose for my project the creation of a concrete vessel to pasteurize water using solar energy. This design, if widely used, would combat the issues that come with open cooking fires; it would be manufactured from concrete so that it could potentially be mass-produced using 3D concrete printing.

This document presents my Honors Project as a synthesis of Design Thinking, a human centered approach to innovation that draws from the needs of people and the possibilities of technology. It includes the context of my project and the health-related issues I have addressed with my design. Some of these issues are the contaminants that exist within water sources and the consequences that come with currently used energy resources. The design of my concrete water pasteurization device is presented through technical, aesthetic, material, and functional criteria. I describe its use within the traditional rural South African home and how my device fits into the water sanitation process as a whole. I explain the prototyping and fabrication processes I went through including casting and 3D printing. Finally, I touch on some research I have done on possible manufacturing processes and dissemination strategies for the production and distribution of my product.

The opportunity to develop a Senior Honors Project for the design of a Concrete Water Pasteurization Device proved to be both challenging and gratifying. Most importantly, it allowed me to investigate and test my design skills through a self-directed project that required interdisciplinary research and knowledge, exploring design processes and testing, and personal motivation. This process has not only been an

integral part of my education, but has helped to shape me as a designer for future endeavors.

ACKNOWLEDGMENTS

There are many people I would like to thank for helping me throughout my Senior Honors Project. Firstly, I would like to thank Evelyn Tickle for mentoring me and and encouraging me throughout my whole project. She has taught me everything I know about concrete. She taught me to accept failures, accept them, learn from them and grow from them. I wouldn't be where I am if she hadn't given me the knowledge and encouragement that you did. Thank you, from the bottom of my heart.

I would also like to recognize Audrey Barnes, my Industrial Design professor. She motivated me and drew me into Industrial Design. I have learned so much from her over the course of these past four years. The things I've learned from her, the wisdom I have gained from her, and the persistence she has have taught me have helped me become the designer I am today.

I would like to acknowledge Teresa Harris, Brian Augustine, and the Honors Program for giving me the opportunity to participate in the Honors Seminar Abroad in South Africa. This was an incredibly meaningful experience for me during my college experience and contributed substantially to the goals for my future and to the development of my Senior Honors Project.

I would like to thank Dr. David Owusu-Ansah for allowing me the opportunity of participating in a JMU Summer in Ghana and Internship. My experience in Ghana opened my eyes and was what first helped me realize that I would like to use my Industrial Design degree to help developing countries develop in the most sustainable way possible.

I would like to thank Sneha Patel for assisting me in the later development of my project. Her support and advice greatly contributed to the success of my final exhibition and all of its moving parts.

I would like to recognize Jack Fanning for facilitating me in the mold fabrication process. He has the most inventive ideas and advice. He was essential to the successes I had and always lent your encouragement during the failures.

I would like to acknowledge Justin Henriques for being such an influential professor to me this semester. He has taught me so much about sustainable development and have helped me gain a better idea of the type of work I wish to do after my time at JMU. I want to design for a purpose, for something bigger than the improvement of daily life – the improvement of daily life for those less fortunate and for the improvement of our declining environment.

I would like to thank the College of Visual and Performing Arts and its faculty for the Undergraduate Research Grant I received. This was essential to my project and it was an honor to be chosen to receive this grant. Knowing that the CVPA believed in me to achieve my goals within this project meant the world to me.

Lastly, I would like to thank all of my family and friends for their endless interest in my project and their encouragement.

ABSTRACT

In the rural areas of South Africa, as well as many other developing countries, people cook food and sterilize their water by heating over open fires. Many times the fires are inside of homes, which more often than not are very small. Children will often be the ones to tend to the fire, out of necessity while parents and other family members are tending to other work and needs.

The purpose of my Senior Honors Project was to design a concrete vessel that can hold water and heat the water to pasteurization (149°F) when exposed to sunlight for an extended amount of time, that can also be mass-produced locally where needed on a 3D Concrete Printer. This product could reduce the need for open fires in the average low-income home in a developing country, and make the process of heating water safer, reducing injuries and deaths in children related to open fires in children.

This project was mostly concentrated on the prototyping and fabrication of the product itself. In order to create a hollow concrete water vessel, I had to create a mold to cast the concrete in. I used methods such as 3D modeling and 3D printing in early stages of prototyping a mold to cast the concrete vessel. After that, I explored other methods and materials used in the process of mold making such as plaster. I experimented with different mixtures of concrete and different methods of casting. In the end, I combined both digital fabrication methods and traditional methods of mold making to create my final form. I explored different sizes, different wall thicknesses, and different exterior structures and aesthetics of my intended product. In the end I made substantial progress toward a working prototype, and developed the procedures to manufacture the concrete vessel by pouring.

The final Concrete Water Pasteurization Device prototype depicts a form, size, weight, and functionality that meets the criteria for the design. My project will require further exploration and investigations, such as the compatibility and effectiveness of the product itself, potential manufacturing and dissemination processes.

PROJECT NARRATIVE:

A Concrete Water Pasteurization Device

for Third World Countries

CONTEXT AND ISSUES

South Africa has a population of about 54,818,635 people. Of that population, 29,602,063 people are living below the poverty line. Although South Africa is very developed as a country in Africa, there are still parts of the country where people are living in extreme poverty. In rural areas of South Africa many people live in traditional African homes made out of local and found materials. Many are without running water and rely on local water sources for drinking water. These water sources can vary but there are still 12 million to 14 million people living in South Africa that are without access to safe drinking water.

The most common water source in South Africa is the borehole pump. People without running water in their homes have to walk long distances to fetch water for their family. The average distance walked to get to a water pump is approximately six kilometers. The average family size in a rural town in South Africa is five people (1). The recommended daily intake of water is 1.7 liters (2). That means that the average family living in a rural area in South Africa has to gather about 8.5 liters of water each day as a basic necessity for everyday life. A visual representation of this can be seen in Figure 1.

Figure 1: A Summary of South Africa

In the rural areas of South Africa, as well as many other developing countries around the world, people cook food and heat their water over open fires. Many times the fires are inside of homes, which more often than not are very small homes. Children are

often the ones to tend to the fire when parents are away or busy, working outside the home.

Children of a young age living in rural areas of South Africa, as well as in many other developing countries, are often given responsibilities beyond what is typical of that age group in the developed world. Some of these responsibilities include taking care of their siblings while their parents or caregivers are away, fetching water, and gathering fuel for the fire. The children will tend to a fire, cook, or boil water, which all can inadvertently cause accidents and house fires. In crowded living spaces a single house fire can have disastrous effects on a community.

The child mortality rate from fire-related burns in low-income and middle-income countries was 8.7 per 100,000 populations in Africa during 2004 (1). Although fire causes the majority of burn-related deaths in children, scalds and contact burns are an important cause of overall morbidity from burns and a significant cause of disability. Nearly 75% of burns in young children are from hot liquid, hot tap water, or steam. Infants also run a significant risk from burns, even in developed countries (1). There are also costs to the children and their families from repeat hospitalization, the need for long-term rehabilitation, lost school days, possible future unemployment, social rejection and other psychosocial issues.

The smoke created by an open cooking fire can create many problems as well. These problems are associated with both the health of the user and the condition of the environment. People who are using these open cook fires are exposing their lungs directly to the smoke being created by the fires. When the fire exists within the home they are putting themselves in an enclosed space with the smoke. In addition, without

any forms of ventilation they are trapping the dangerous smoke particles within their homes.

More than three billion people worldwide rely on fuels such as wood, dung or coal to fuel their basic energy needs to cook, boil water and heat their homes (2). Consequently, nearly 4 million people die each year as a result of inhaling lethal smoke from kitchen stoves and fires. Most of these victims are women and children that are under the age of five. Additionally, half of deaths in children under five with pneumonia are attributed to indoor air pollution. Furthermore, over one million people die each year from chronic obstructive pulmonary disease, again attributed to prolonged exposure to indoor air pollution. (3)

The fuels that people are relying on in rural areas of South Africa such as wood, dung, and coal are not renewable energy resources. The carbon emissions from these energy resources are contributing to the pollution of their country and in the end, the world. South Africa is one of the world's largest carbon polluters (4). South Africa needs to reduce their dependence on what is being called "dirty energy". Wood-fuels have also been linked to forest degradation, deforestation, and respiratory diseases (from indoor smoke). Major efforts are being directed at reducing and replacing their use. Many proposals from the area of design, engineering, environmental health, and community development are focused on the introduction of alternative ways of providing safe, clean drinking water to rural communities without the need to utilize non-renewable resources. A visual representation of the different energy resources being used and their individual affects can be seen in Figure 2.

Figure 2: Energy Resources Being Used in Rural Areas of South Africa

With a product such as my concrete water pasteurization device, many issues associated with the traditional cook fire would be eliminated. Even though concrete can have the ability to heat water to high temperatures, concrete is not hot to the touch

when exposed to prolonged sunlight. This would eliminate the fire all together to pasteurize water. This means children will no longer be suffering from injuries caused by flames. Additionally, without the fire, there will no longer be a presence of smoke to contribute to disease and illness or air pollution. Lastly, my product is sustainable in a way that does not require the use of unclean energy resources. By eliminating the use of these dirty energies, the the surrounding environment and air quality will certainly be improved.

People living in rural areas of South Africa are also encountering many issues with the quality of the water they are collecting from various water sources. Some water sources include borehole water pumps, still water such as ponds, and moving water such as rivers. With all of these water sources there are contaminants in the water. Borehole pumps are often one of the safest places to retrieve water from. Although that is true, I learned from a source at an NGO called SNV that specializes in water sanitation and hygiene that the water that comes from these pumps can sometimes contain high amounts of pesticides and high amounts of sodium. Water from rivers, or any moving body of water, typically isn't as safe as borehole water but is better than still bodies of water. Moving bodies of water are often contaminated with fecal matter from defecation and trash pollution (5). Still bodies of water, being the worst place to retrieve water from, can contain parasites that cause illness and even malaria, as mosquitos breed in still water (6). A visual representation of each of these water sources and the contaminants in each source can be seen in Figure 3.

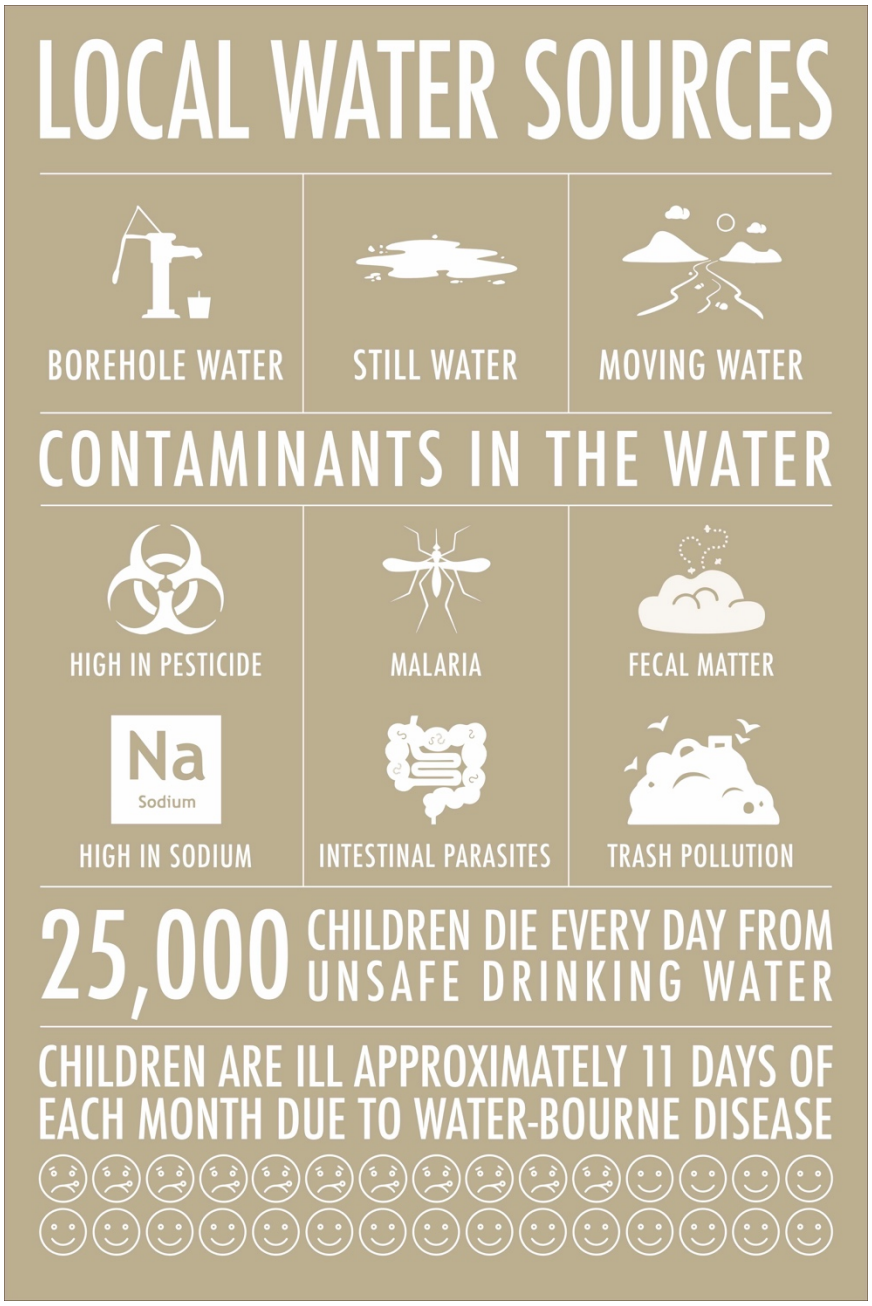

Figure 3: Local Water Sources and Contaminants

Drinking unclean water with contaminants such as the ones previously mentioned can have very dramatic affects on people and especially children. Unsafe drinking water affects children more drastically than anyone because their bodies are

not fully developed. Undeveloped bodies mean undeveloped immune systems. They are at a higher risk of contracting an illness from the water and will have a harder time fighting that illness off. In rural Africa, children are ill approximately 11 days of each month due to water-borne illness. These illnesses acquired can also develop into chronic health issues. Some illnesses, if not treated, can even result in death. Every day, twenty-five thousand children die from unsafe drinking water. (7)

Access to safe, clean water is a basic human necessity. In developing countries and in particular, rural areas, traditional means of accessing water are followed base don cultural and societal norms. In rural South Africa, this includes walking long distances to a water source on a daily basis and then making the water safe to drink by heating it on an open fire. Aspects of this tradition are vital to everyday life; the ritual of fetching water for women and children is an important part of the cultural norm in Africa. Without disturbing this practice, there is still an important opportunity to rethink how to make water safe for families, reducing accidents with open fires and the associated problems with smoke, pollution, and non-renewable resources. This project is the design of a device that aims to better understand these issues and provide an alternative to the current process of collecting, storing, and sanitizing water for individual families.

CONCRETE WATER PASTEURIZATION DEVICE

DESIGN AND FUNCTION

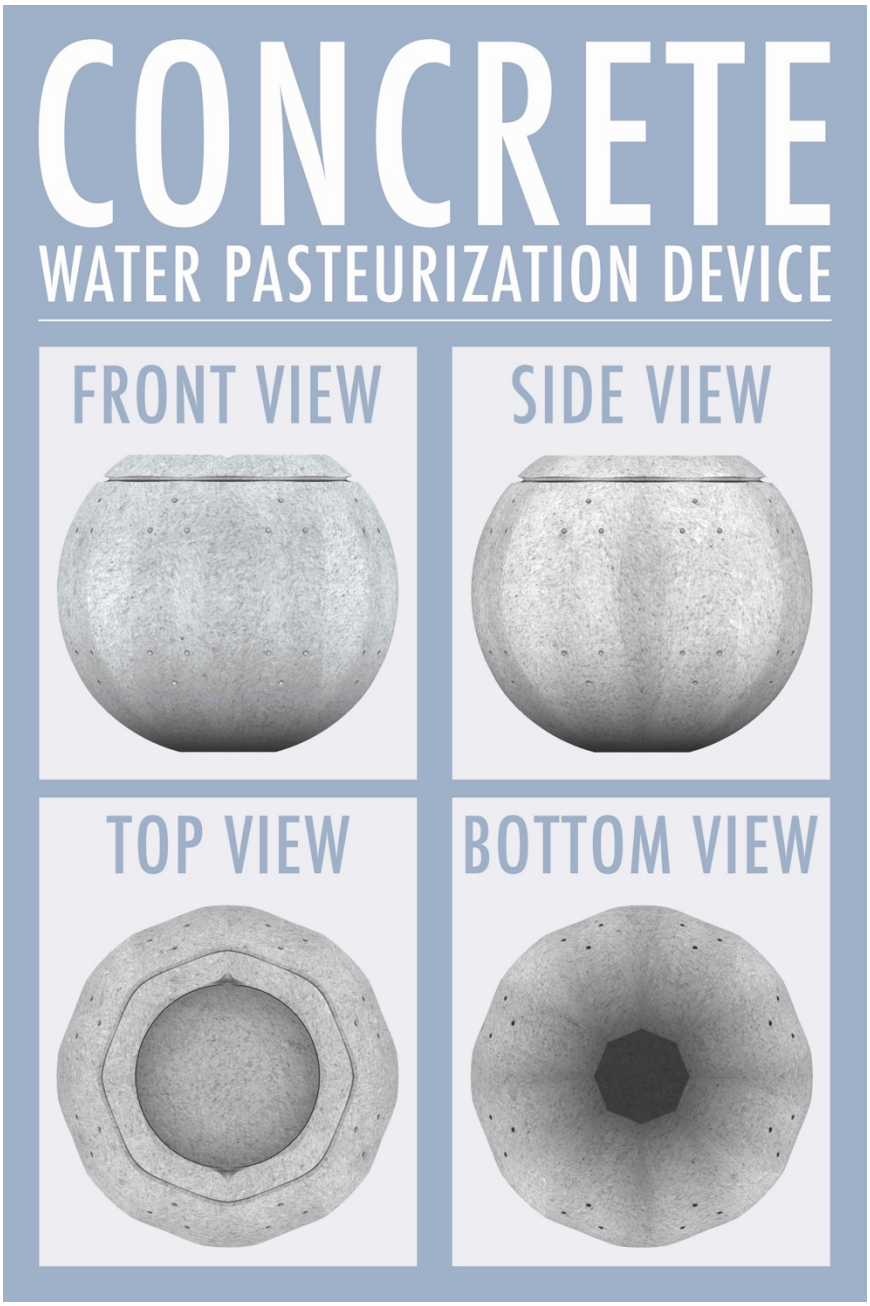

Figure 4: A Rendering of the Concrete Water Pasteurization Device

As a finished product, my concrete water pasteurization device will appear as shown in Figure 4. It will be made out of a mixture using PPC Cement, which is the local cement of South Africa, as well as sand and water. It will have a consistent wall thickness of about one centimeter. The water vessel will be twenty-five and a half centimeters in diameter and hold 8.5 Liters of water. That is enough water to provide an average family size of five with their recommended daily intake of water.

The product as a whole will consist of two component pieces: The vessel itself and a filter that attaches to the top. The filter that attaches to the top is meant to aid in the overall sanitation process of the water. The filter will be made of a ten-micron polyester felt fabric and have a silicon elastic band that wraps around the entire edge of the filter fabric. The vessel itself has a slot for the filter to fit into when it is pulled over the top. The filter will be fifteen centimeters in diameter. A visual of each of the component pieces and each of them being used together can be seen in Figure 5.

Figure 5: Component Pieces of the Water Pasteurization Device

Each component piece plays an important part in the over sanitation process of the water. There are three main steps in the water sanitation process for household level drinking water. These steps are sedimentation, filtration, and disinfection.

When first collecting water from a water source such as a pond or river there will often be some kind of sediment in the water such as sand, silt, or clay. To remove this sediment, the water needs to go through a process called sedimentation. This is a natural process in which the sand, silt or clay is carried to the bottom of the body of water and forms a solid layer. My product will use the process of “simple settling” to remove the sediment. This process will be done by letting the vessel of water sit without moving for an extended period of time and then pouring the water into another vessel. This process may need to be repeated up to 3 times.

Once the sediment is removed from the water it is ready for the filtration process. As mentioned before, this will be done by using a ten-micron polyester felt fabric filter. This kind of filter will be able to filter out anything that is ten microns and larger in size. Ten microns is one fifth the width of a strand of hair. This filter will be able to remove Helminthes and Protozoa that may be in the water. Filtering these contaminants out will also improve the taste, smell, and color of the water.

The last step that will need to be completed to completely sanitize the water will be to disinfect the water. This process will free the water from infection by destroying any harmful microorganisms that may be in the water. The disinfection will be done via solar heating. When the concrete water vessel is sitting in the sun for an extended amount of time, the concrete will absorb the heat from the sun and radiate that heat throughout the water inside. This phenomenon will ideally be able to heat the water inside to pasteurization temperature, which is 65 degrees Celsius. This process will kill just about all germs, viruses and parasites that may be in the water. Each of the processes I have described may also be seen in Figure 6.

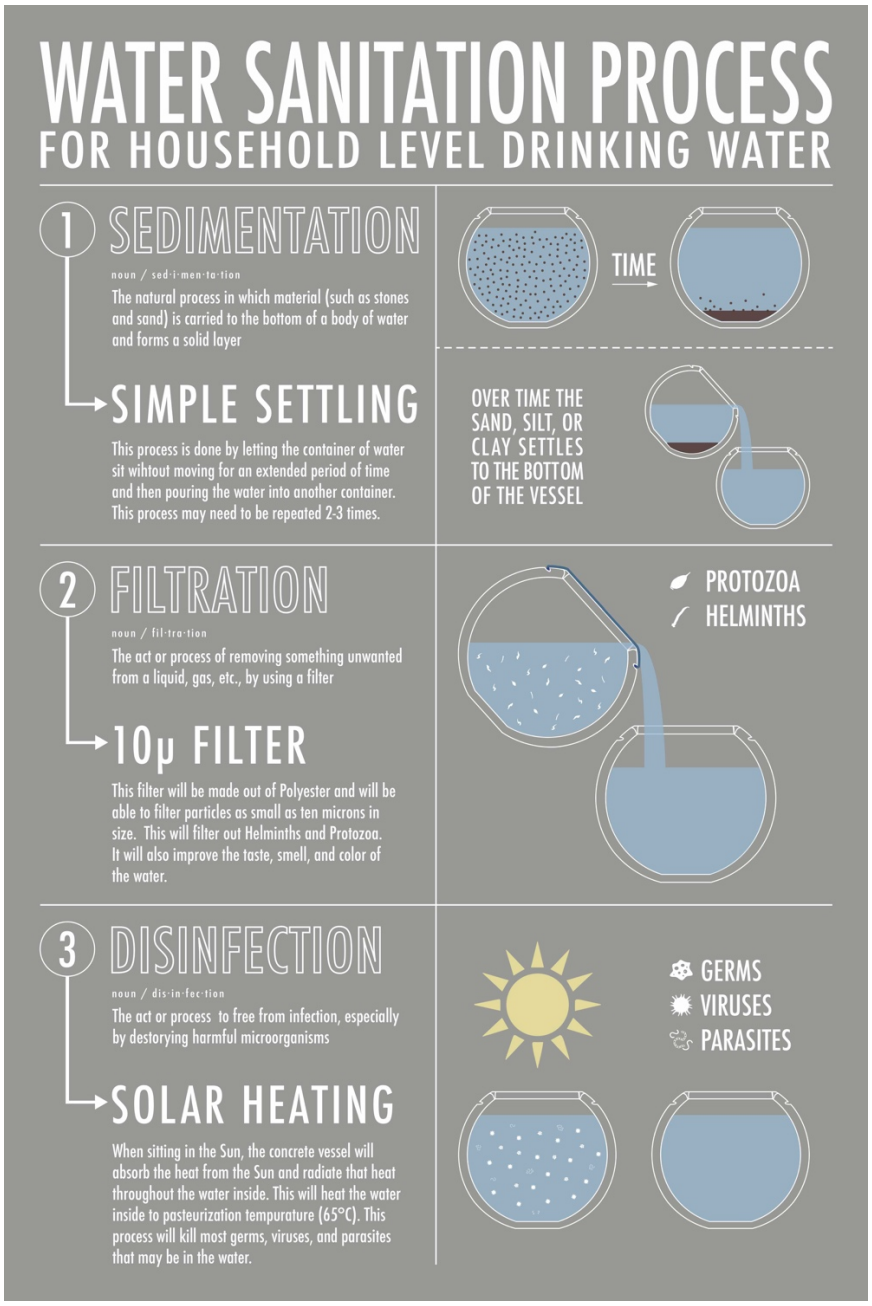

Figure 6: The Water Sanitation Process for Household Level Drinking Water

Once the water was gone through each of those processes, it will be safe to drink. Users will no longer have to worry about suffering from the lethal affects of the water's contaminants.

In figure 7, examples may be seen of how my concrete water pasteurization device might look in everyday use within rural areas of South Africa.

Figure 7: The Concrete Water Pasteurization Device in Real World Scenes

In Figure 7, a rendering can be seen in the top right corner of what it might look like when a group of women and their children go to gather water from a well using the Concrete Water Pasteurization Device. The top left corner image shows a woman gathering water from a still body of water. Both of those images show different kinds of water sources being used and different ways of people gathering the water.

The two middle images show what it would look like if a child were carrying the vessel and what it would look like if a woman were carrying the vessel. Both images show the vessel being carried on top of their head. It is common practice in rural South Africa for goods and objects to be carried in this way. The storing of necessities, from grains or other food items, to water, typically utilize vessels, made of clay, ceramics, and other local materials. The Concrete Water Pasteurization vessel is a designed to be a moderate weight that can easily be carried on a child or grown woman's head. It has been said even that women in Africa can carry a load that is up to 70% of their body weight (8). Beginning to carrying loads on top of the head at a young age allows their neck muscles to grow strong enough to make such a pay load possible.

The bottom two images show what the vessel might look like when the vessel is sitting out in the sunlight for the solar heating disinfection process. The vessels may be monitored by the children while the parents or care givers are away as shown in the image to the left at the bottom. The children are managing the chores still but since minimal effort is required by the children during this process, they may have time now to study for school, play, and so forth. On the other hand, the water vessels may be left unattended during their disinfection process. There is no harm in leaving them unattended. The traditional open fire would never be able to be unattended as doing so

could lead to a house fire, but with my concrete water pasteurization device, there is no fear of that since it does not require any sort of flame.

FABRICATION AND CASTING

Over the course of the project period, a majority of the effort was put into the prototyping of the design. In the beginning I used methods of digital fabrication such as 3D modeling in Rhino and 3D printing. I used these methods to first prototype different kinds of molds to cast my hollow concrete sphere. When I first began doing this, the concrete lab in the Studio Center was not yet up and running. Therefore, I turned my living room into my very own concrete lab, complete its very own couch to wait out the cure time of my forms.

The mold that I was first experimenting with looked like two halves of a square. On the inside it was two half circles with a hole on the top of one of them for the concrete to be poured into. I made the inside hollow by placing a Styrofoam ball in the middle. When it was done curing I poured acetone into the concrete sphere to melt away the Styrofoam ball.

Some of the initial iterations of molds that I printed on the 3d printer and then tested taught me that you can only prototype molds for concrete so small. Working at too small of a scale was not practical. I quickly learned some important design and fabrication features I had to add to the mold such as holes for the air bubbles to escape that can get trapped inside and a flat bottom so that the vessel doesn't roll around. I experimented with putting the concrete in a plastic bag, cutting a hole in the corner, and using it in a motion such that a 3D printer would, extruding the concrete out from the small hole in the bag. I had some successes and some failures throughout my early working processes. Some of my different iterations of molds and pouring process can be seen in Figure 8.

Figure 8: Early Fabrication of Mold Prototypes and Pours

Soon after I was ready to move into the next stages of my mold making process the concrete lab at JMU's Studio Center opened. Once in the concrete lab, I scaled up the size of my mold. I used a ten inch Styrofoam ball as my center piece. I covered it with an even one centimeter layer of plaster and sanded it down until it was very smooth to the touch. This plaster that covered the Styrofoam ball was meant to mimic the concrete vessel. This plaster was holding the place of where the concrete would be poured in the finished mold.

I next built a box out of melamine board, which is a natural release agent due to the properties of its surface, that would eventually create the outer cube shape of my mold. I then covered my plaster Styrofoam ball with wax so that it would not fuse to the additional plaster that I was about to submerse it in. I systematically placed the ball in the very center using wooden dowels and then poured plaster in the entire surrounding space. A diagram of the mold making can be seen in Figure 9 to better understand the process and photos from this process can be seen in figure 10.

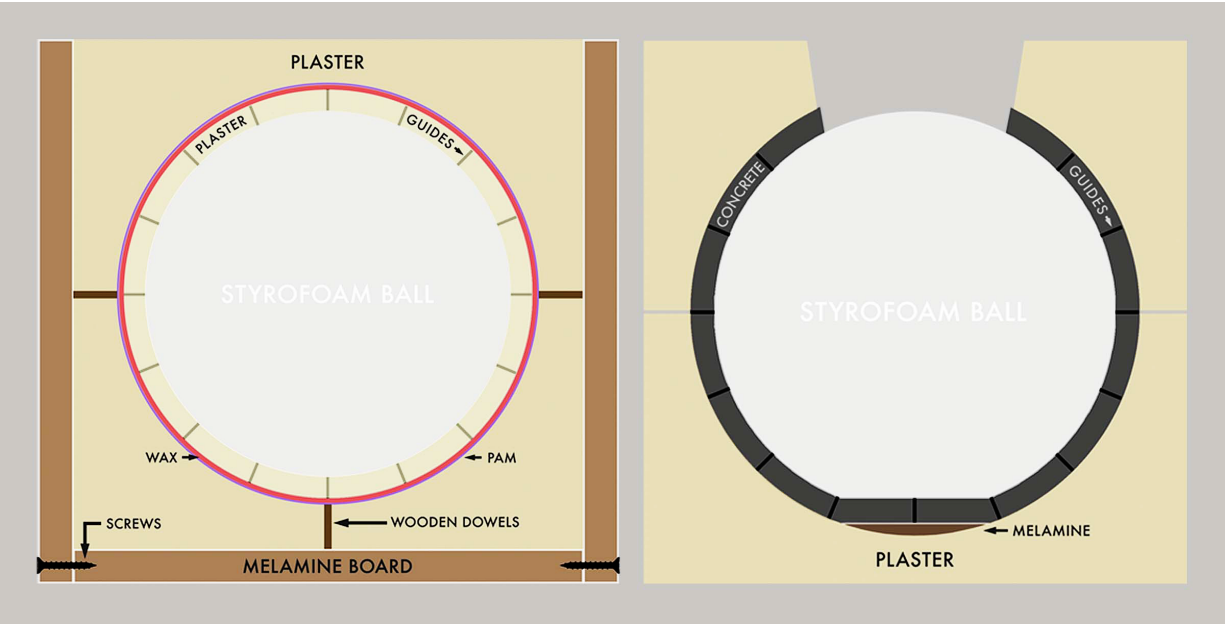

Figure 9: A Diagram of My Mold Making Process

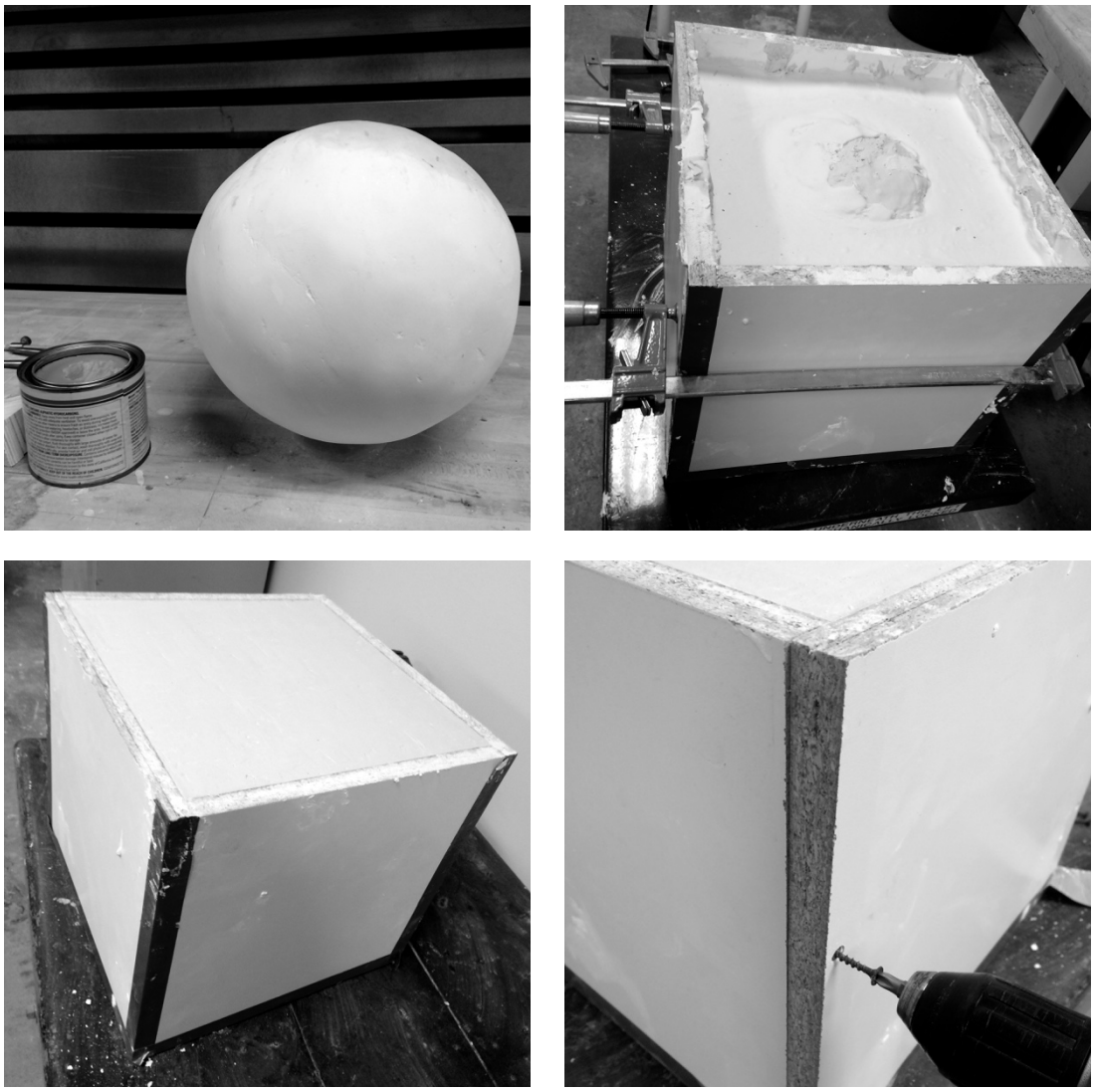

Figure 10: Casting My Plaster Mold

Once I had removed my plaster mold from the melamine box I sawed it in half to get the two halves of my mold. I then carved out an opening at the top to pour the concrete through. This opening would also be where the opening of my vessel is formed. After those final steps, my mold was finished. Documentation photos of this may be seen in Figure 11.

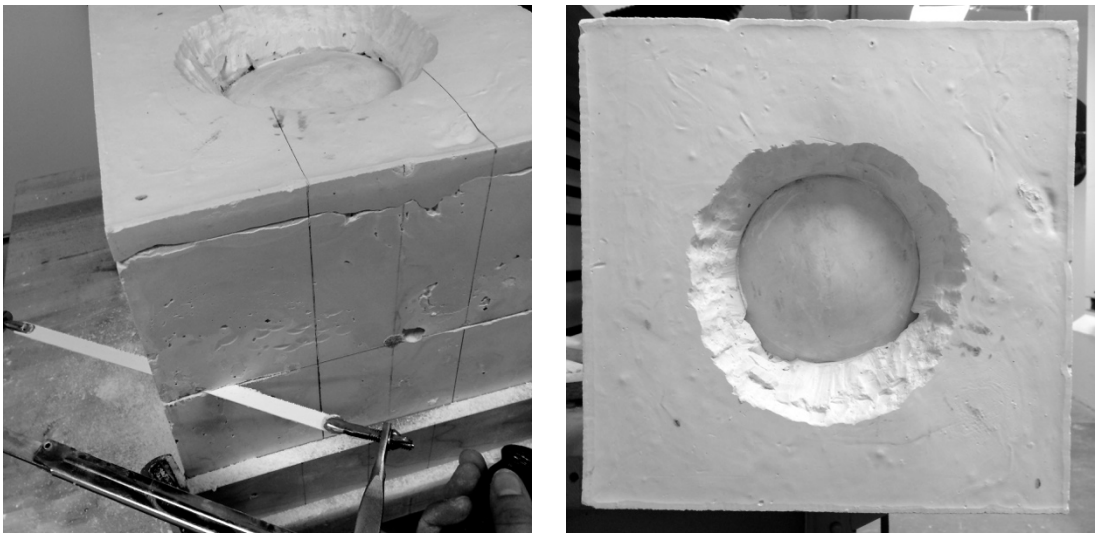

Figure 11: Sawing My Mold in Half and Creating an Opening

My first three pours in this mold were different variations of failures. My first one had giant air bubbles in it. My second one crumbled almost immediately after coming out of the mold due to excess amounts of water in the mixture. The third one went mostly well until the end when it got stuck in the mold. The form got stuck in the top half of my mold (Figure 12).

Figure 12: Concrete Form Stuck in the Mold

I ended up having to saw the top half of the mold in half to get the form out. After sawing the mold in half, I had to put in some effort to reassemble the top of the mold to do my next pour. I used Sculpy, a non-drying clay to fill in the cracks, holes, and gaps in the mold (Figure 13).

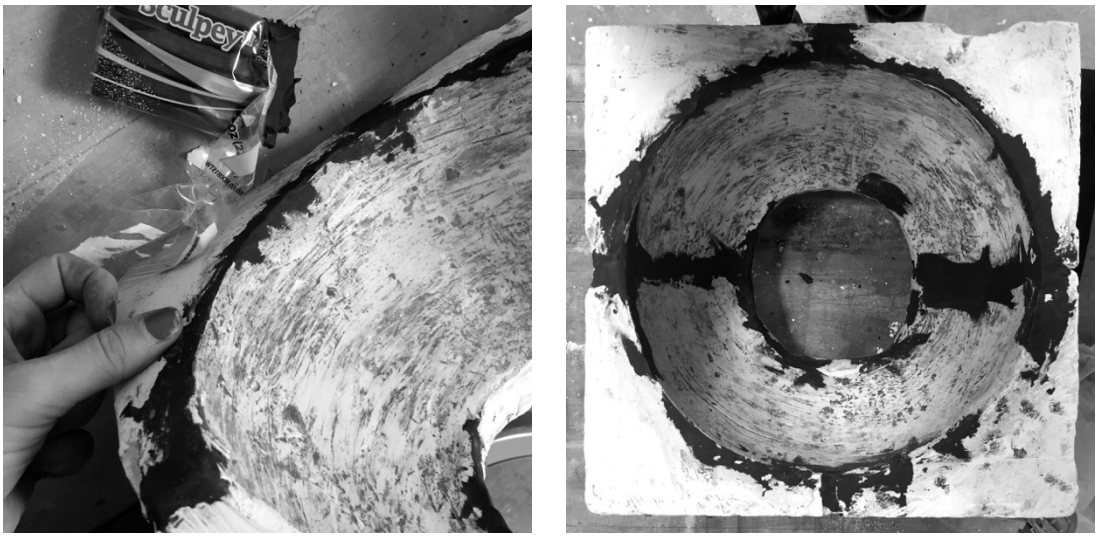

Figure 13: Filling in the Cracks, Holes, and Gaps in My Mold

For my fourth pour I changed my method of pouring. Instead of pouring the whole thing all at once I did it in two different pours, letting the first pour cure for a couple hours before doing the next. I did this because I was encountering too many issues with the Styrofoam ball floating and moving around. For the fourth pour, I strapped the Styrofoam ball in with a clamp so that it would stay stationary. Once the ball was strapped in I poured the the bottom half of the mold. I then let the bottom half cure for a few hours. I textured the exposed concrete to help the next pour attach to the cured concrete (Figure 14). This pour turned out to be the most successful pour I had gotten in over a semester and a half (Figure 15).

Figure 14: Strapping in the Styrofoam Ball and Texturizing the Concrete

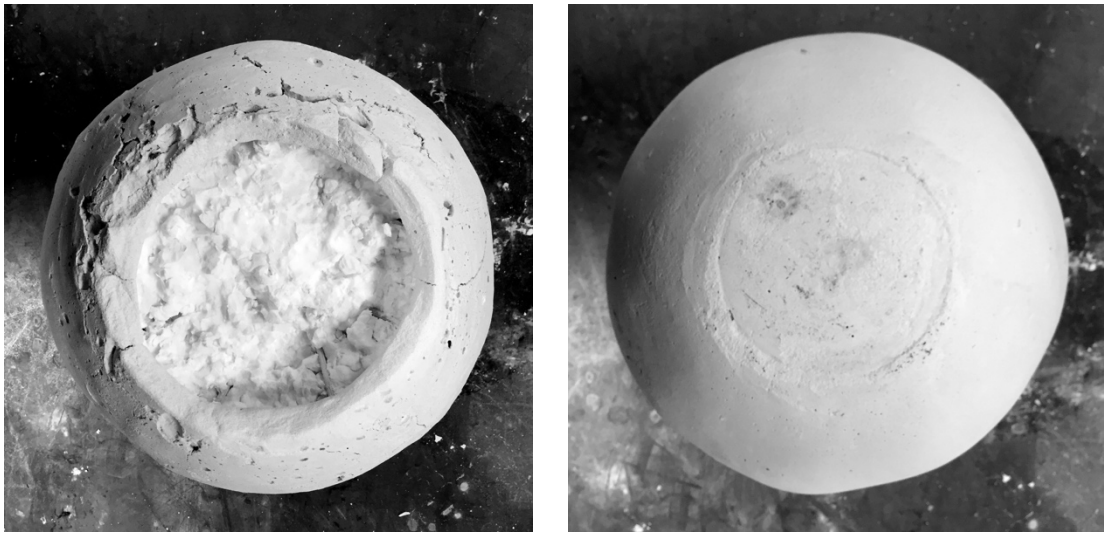

Figure 15: My First Successful Concrete Pour

Completing the first successful pour meant that after much trial and error in the fabrication process, I had developed a working methodology and a skillset that I could now continue to improve upon. It was then time to start experimenting with the exterior structure of the mold. I had already done some iterations of this in the 3D modeling

software, rhino. Some had traditional African patterns drawn from the tradition of ceramic vessels in the area and some had ribs to help stabilize the hands when holding the mold. After those iterations I decided to take an approach to this that wasn't necessarily just about adding to the external surface, but about changing the structure of the surface. I decided to make the outer surface of the sphere with more of a scalloped shape repeated all around. This scalloped shape assisted in the handling of the vessel, as the variations on the form were scaled to the hand and were designed to accommodate the lifting and tilting the object for carrying and pouring the water.

In order to actually make this form I had to go back and alter my mold. I 3D-printed some inserts to fill the negative space between each scallop bump. I then strategically placed these inserts throughout the inside of the mold and secured them with clay (figure 16).

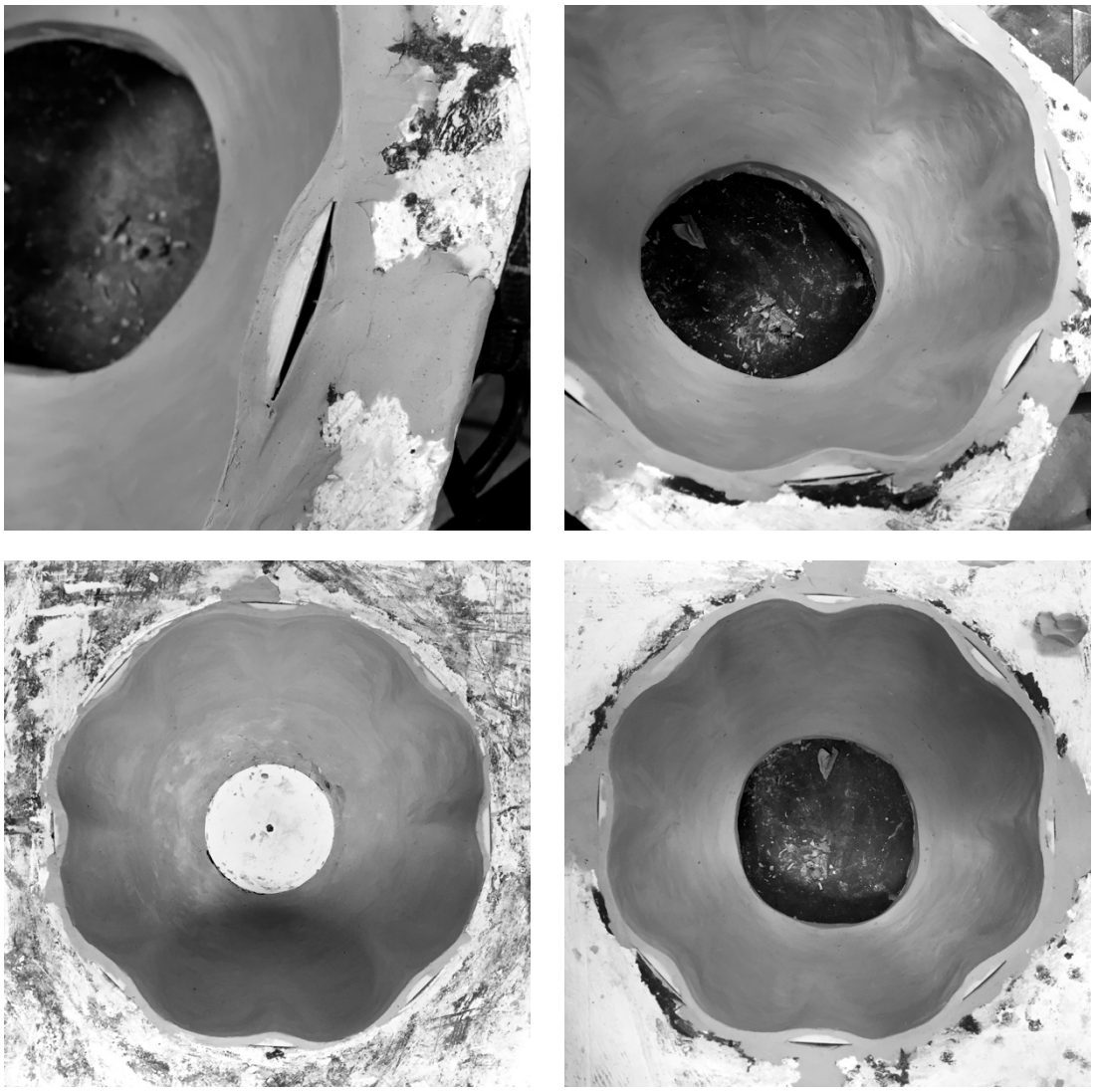

Figure 16: Redefining the Form of My Mold

As a result of adding to the mold, I had decreased the diameter of the inside of the mold. I could no longer use the ten inch Styrofoam ball on the inside without it touching the edges of the mold. Instead I had to moved down to using a nine-inch diameter Styrofoam ball. This would end up be misleading in the final form. Since this form would end up with a denser wall thickness, it would make the vessel much heavier than it would be in actuality. This was compromise that I had to accept within the

process. This would be the last pour I would be able to do before having to prepare for my exhibit, so I came to terms with it. I would now have one version of the vessel to represent the ideal wall thickness and one to represent a variation of what the external structure could be like. This pour turned out to be a success, confirming that the trial and error process is so vital to prototyping. (Figure 17)

Figure 17: My Final Pour and Final Form

A more in depth account of the fabrication and casting of my project can be found in my journal of progress, which is in the Appendix.

MANUFACTURING AND DISSEMINATION STRATEGIES

I have considered many ways and methods for my product to be manufactured. I have also explored various approaches to the dissemination of my product as well. In the end I decided on three different ways for my product to be manufactured and distributed. My ideal method of manufacturing is 3D concrete printing.

In the first option, a 3D concrete printer would be given to a school, or a similar kind of community center, institution, or organization. The school would be the home of the mass-manufacturing of my concrete water pasteurization devices. Locals and teachers would learn how to use the 3D concrete concrete printer and be able to teach children about it and its capabilities as well. Consumers would go through the school to purchase or acquire their concrete water pasteurization device. This method would create jobs, provide learning opportunities for children and raise awareness of the technological advancements happening in the world as well.

The second option would also use 3D concrete printing for the manufacturing method. In the second option though, the concrete vessels would be manufactured outside of the country and then shipped to the users. Some advantages of this option would be that the location where the vessels are manufactured could be run by highly trained fabricators. This way there are no issues with the learning curve that comes with this new and advanced technology. Yet, it is less than ideal to simply import a product into a location of need. While the mass manufacturing of 3D printers in a larger factory could increase the efficiency and quantity of the products, it does not allow for two important factors in the eventual use of the product: the first is the opportunity for locals

to learn how to make this product, utilize a new technology, and craft their own objects. The second is that there is the opportunity to teach about an object's use when one has the chance to see how it is made. Both of these criteria are important to the design.

The last option is for the concrete water pasteurization devices to be created by the users themselves through a sort of do-it-yourself kit. The users would be provided with a list of materials needed, all of which would be able to be locally found, and instructions for creating the mold and casting the form. A benefit of this option is that since the manufacturing of it is being done by the user, they could create as many as they would like for no addition cost. A flaw of this option would once again be the learning curve involved. Who is to say that someone else could create this exactly the way it is supposed to be made? And if not, would it even work?

A brief diagram of each step in the process of all three potential ways of manufacturing can be seen in Figure 18.

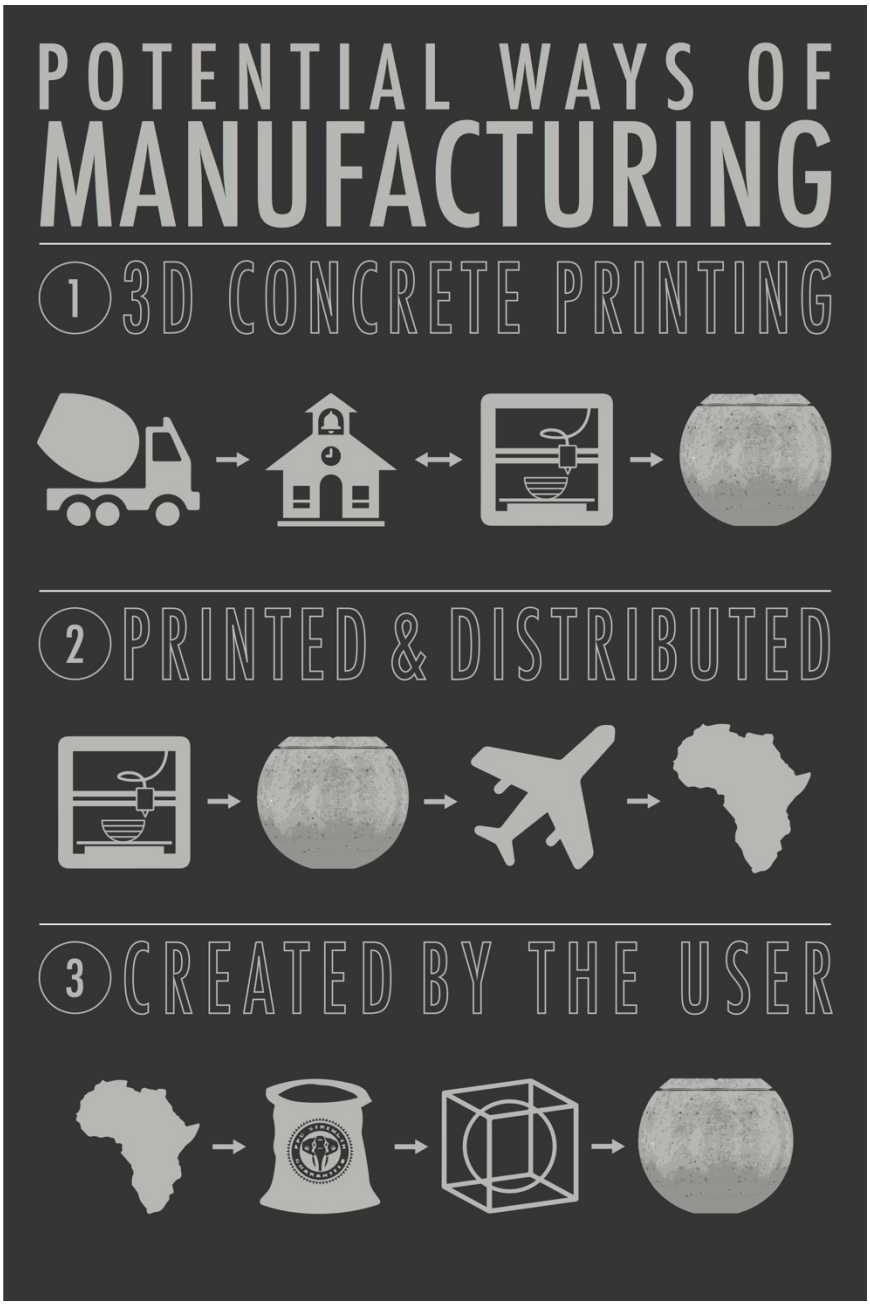

Figure 18: Potential Ways of Manufacturing

Pros and cons can be found within each option. The next step to take in this process would be to further identify price points on my product and the manufacturing costs, for each option. After that I would connect with an NGO and further develop the

best way to implement this product. As with any designed object for everyday life, there are many critical factors that must be synthesized for its holistic success. The Concrete Water Pasteurization Device is a functional object that addresses a basic need, but it is also an object of culture. Therefore, it has the potential to become a lasting part of tradition and history or to simply be a device that soon becomes obsolete. Design impact requires an understanding of how aesthetics, history, culture, functionality, production, economics, and technology come together to produce better products for the world at large. This project exemplifies these many criteria and goals; I look forward to continuing to evaluate the device in terms of its full application and purpose for the people of rural South Africa.

APPENDIX

JOURNAL OF PROGRESS

Journal Entry One – Sept 4, 2015

This is the first journal entry for my Senior Honors Project. I have been anticipating the beginning of the semesters all too much this summer. Thinking about what I want to do for my project and all that it entails, and then thinking about how I only have two semesters to do it, causes me a lot of anxiety. This teaches me one lesson before I even get started and that is to stay in the moment. I have never done a project that is something that I conceived and am doing on my own. One thing I know will be hard for me is sticking to a schedule. It is easy for me to manage time when I deadlines are given to me, but now I'm giving myself the deadlines. How hard will it be to stick to my guns? To help with this I have created a schedule for myself with milestones and deadlines. I hoping this will help me stay on top of my plan.

Journal Entry Two – Sept 11, 2015

I've learned much in only one week. On my schedule for this week was to do sketches of my product, sketches of different ideas for a mold, and Rhino renderings of both my product and potential molds, and to research local materials in South Africa. First, I learned from my advisor Evelyn Tickle that I need to work on my sketches more. Currently I have a very "sketchy" type of drawing. In order to communicate my ideas more clearly I need to make them less sketchy with more clean and precise lines. This is a good thing for me to learn for the real world as well. How will I ever communicate a design idea if my drawings cannot be clearly understood?

I also learned what kind of materials South Africa has to offer to make a concrete mixture. They have all the right ingredients there. Concrete is a mixture of water, an aggregate (being sand or gravel which is in abundant supply there), and cement. In the U.S. we would use ordinary Portland cement, so I researched what kind of cement is used in South Africa. In South Africa a different variant called PPC Cement is used. This research is helping me understand what my local mixture might look like. I also researched something called Earth in Concrete. Earth in Concrete is an innovative premixed concrete product that has very low carbon emissions and embodied energy. This, along with everything else, will be something to keep in mind.

Journal Entry Three – Sept 18, 2015

On my schedule for this week was to continue research from last week. At first, I was having a hard time conceptualizing what this mold might look like, as I have never made a mold to cast something in concrete, nor have I ever tried to cast a hollow sphere – which I am realizing is very hard to do. After a sit-down and a drawing session with Evelyn, she helped me to understand how a mold needs to work for this. It needs to be a strategic set of pieces that fit together and make the mold. I am eager to get my hands dirty and start mixing some concrete.

I went ahead and 3D printed my first mold. From the outside, the mold looks like two halves of a cube. On the inside it is two half spheres with a hole on the top of one of them for the concrete to be poured into. I will make it hollow by placing a Styrofoam ball in the middle. When it is done curing, I will pour acetone into the concrete sphere to dissolve away the Styrofoam ball, which will then make it hollow.

Today I made my first attempt at pouring, and it was a glorious failure. I learned quite a lot. I poured first with only cement just to get a feel of what working with this kind of material will

be like. First, I learned that my mold was much too small. I was having a lot of trouble pouring the concrete into the far-too-small half-inch hole. Second, I learned that coating the mold with Pam cooking spray is a necessary step that I failed to take, so that the concrete will not stick to the mold. When I was taking my mold apart to see what I created and saw that it was stuck in the mold, practically fused to the plastic, I had a good laugh at myself and thought, well, things can only get better.

Journal Entry Four – Sept 25, 2015

There's a phrase that we have in my class for when we think of new ideas and start to prototype them, "fail early and fail often". So it's time to try again. This week I printed a mold that was about twice the size of that one I made last week. The process of printing this mold however took quite long, however, about 10 hours to print both halves. This was a two-day effort. That being said, while my mold was printing, I had a lot of time to work on other things. This week I met with two key people on my project committee, Dr. David Owusu-Ansah, who I went to Ghana with, and Teresa Harris, who I went to South Africa with. When going to speak with Dr. O-A he gave me some really great feedback. He suggested some further research I should do to support the need for this project more than the reasons I had already given. My initial reasoning behind why a product like this needs to exist is the mortality rate in children due to open cooking fires in homes and other dangers that brings along with it. But there are other reasons that I have researched and added, including smoke inhalation from open cooking fires in homes, and the fact that most current energy sources such as wood are not effectively renewable (because the rate of use exceeds the rate of regrowth). Dr. O-A also put me in touch with a man named Kofi who went to JMU and now works in Ghana, for an NGO called SNV. SNV focuses on agriculture, renewable energy, and water/sanitation and hygiene issues. SNV's

goal is to catalyze the sustainable development process. After reading about SNV and what they do, I thought that they would be a perfect NGO for me to reach out to seek collaboration. So, I did. I emailed Kofi a detailed description of my project and told him that my end goal is to learn how to implement this in a developing country such as Ghana. He took my information and said he would discuss my project with an advisor of his and get back to me. I am very excited about this! After speaking with Teresa, she emailed some contacts of hers in South Africa to try to find some similar connections for me. I am still waiting to hear back from her.

Journal Entry Five – Oct 2, 2015

I made my next attempt at concrete pouring. This time things went a lot better. Probably the most exciting thing for me, which may seem insignificant, was that my concrete cast actually came out of the mold. (I did not forget to Pam my mold this time!) The result was a lot better this time. The opening at the top was a much better size to pour the concrete into. An issue that I encountered was that the Styrofoam ball in the center floated, making it harder to pour the concrete in the top opening. I think that pouring will get easier with practice. Another thing that might make pouring easier is using a transparent filament that I got for the 3D printer in my next mold, to hold the styrofoam. I also ordered a flexible filament to print a mold out of. I am really excited to experiment with this!

I also head back from Kofi and his advisor at SNV. His advisor, Jesse, told me that he thought my project proposal was exciting and innovative. He recognized my project as an "integrated technology embracing household water treatment and storage and renewable energy technologies." He was spot on. Unfortunately, after that he told me that, "SNV does not have any on-going water supply projects where my design/innovation can be piloted." He did however tell me that I should look into grants that support these types of innovations. He told

me that my technology needs to be tested and piloted with a well-documented outcome, before I produce a funding proposal for big donors. He ended his email to me by saying when I did submit a proposal and concept note that, “with permission from my sector leader, I can support the concept note development.”

This got me very excited to have a functional prototype to start being tested.

Journal Entry Six – Oct 9, 2015

There has been a significant amount of progress this week. I heard back from the contact that Teresa gave me, Ncho. He gave me very valuable information on water sanitation. He helped me to realize that in such rural areas, where water quality can be very questionable, it takes a lot more than just pasteurization to clean the water. He told me that the World Health Organization looks at about 200 contaminants as a guideline for drinking water, and that South Africa specifies about 25 parameters that water has to comply with. There are many ways of removing contaminants from water. Ncho told me many of the ways, but after reading all the information he gave me, I did additional research on where people in rural areas of South Africa get their water and what kind of contaminants can be in it. In rural areas, many people get their water from boreholes or surface water, such as rivers. From studying the South African Water Quality Guidelines, I learned about the different contaminants that are tested for in water for domestic use, that is, for drinking and food preparation. I learned a lot and plan to tie this informationinto my design. There’s no point in making a water pasteurization device if you still won’t be able to drink the water afterwards.

I sent my project proposal to a contact at SNV, who then gave it to an advisor to look over as a potential project for them to collaborate on. I suspect I will be hearing back from them next week.

My concrete pours have also improved. The pours last week were successful but had to be modified. I 3D printed a new mold that had a slightly flat bottom to the bottom piece of the mold, and air holes in the top piece of the mold. I made the bottom slightly flat so that the structure could sit straight up without rolling over, and I made the top with air holes so that there would be fewer air pockets.

Moving forward, I am going to be thinking about how big I want my product to be in real life. I will be considering how much water it will need to hold, and what the weight of the structure will be. I will also be thinking about how to 3D print the mold for it, considering the small size of the print bed I have to work with. I have realized that it will have to be more than two pieces. I am looking forward to creating new models.

Journal Entry Seven – Oct 16, 2015

This week I prepared to give my midterm presentation to my project committee. This involves creating a poster that clearly outlines what my project is, how it works, who my intended audience is, why they need a product like mine, what my process has been so far, and what my process will look like moving forward.

I got very good feedback from Evelyn, Audrey Lankford Barnes, Dr. O-A, and Teresa. Some feedback I received was that the vessel needs a bigger opening at the top, and that it needs to have more capability to roll. A really good question that they asked me was how might the water be preserved within the vessel? This brings up an opportunity for further research, but also the question of does it need to be preserved? My idea is that this vessel holds the amount of water one should be drinking on a daily basis to stay healthy and hydrated. So perhaps it does not have preservation capabilities because the water inside is intended to be used in one day. Other questions that they asked me to think about were: Why is it better than a solar

cooker? What are the price points? How does it work on winter days? Could one family have a collection of them? Can it be used for other purposes?

In terms of my presentation, Audrey gave me valuable feedback. She told me that, first, I need to start using the metric system because that is the system that my target audience uses. Second, she told me that I need to use the burn victim story in the beginning to really get my audience hooked and pull their heart strings. This is necessary because if my audience during a presentation can hear a story that makes them feel a powerful emotion, they will be more attentive and want to hear about how my product that can help its users.

Journal Entry Eight – Oct 23, 2015

This week I created a new mold for my vessel, based on the feedback I got during the midterm presentation. This new mold is 10 inches in diameter, the biggest mold I have made so far. It has patterns on the inside of the mold to give the vessel's outer surface aesthetics. The patterns in the mold are concave, so that the finished vessel's outer patterns will be raised and be very tactile. The mold consists of eight pieces, that joins together using Lego joints that fit together – believe it or not – just like Legos. The different pieces of the mold consist of four pieces that make up the outermost parts of the mold, a bottom middle piece, two pieces that complete the opening at the top, and a cork-like piece that goes into the mold to make the top opening in the concrete.

It took me all week to create this mold in Rhino. I had to change the kind of joinery, because I originally was doing puzzle piece joints, but those would have been too fragile. The Lego joints are much more sturdy. I redid the model a couple times in Rhino because I would finish it and then realize something I forgot to add.

When I finally took it to the X-Labs to get some help with 3D printing it, I set up my first and largest piece to print, and then saw that just my largest piece was going to take about 17 hours to print. This is the moment when I realized that 3D printing is no longer the most realistic way to be creating molds.

Journal Entry Nine – Oct 30, 2015

After realizing last week that 3D printing was no longer going to be my means of mold making, I felt like I was at a kind of at a stand still. I had to have conversations several people who have had experience in mold making. Creating a mold to make a hollow sphere is no easy task. After much thought and conversation, I now have two methods of how to move forward and make a larger mold for my vessel.

One method will be to make a shell to form the vessel out of clay. I will be working in the ceramics studio on the potter's wheel to make this. I will make two halves of a sphere, or two bowl shapes, and then carve the outer patterns of the vessel on the inside of the two halves. This will be what makes the vessel's actual shape. Additionally, I will have to create a structure to attach to the clay parts to give it a sturdy outer structure to support the heavy concrete. The other method I have for creating a mold, which I think will be the better method, will be to get a large Styrofoam ball, build off of that to make a mock vessel, and then place it into plaster with a release agent to then create the larger mold.

I have ordered my Styrofoam balls already and am now waiting for them to come in. In the mean time I will be going into the ceramics studio, working on an alternative method so that I won't be wasting time.

Journal Entry Ten – Nov 6, 2015

I chose to go forward with the second method of mold making mentioned in my previous journal entry. My Styrofoam balls came in the mail. I began my mold-making this week. I first decided that I am going to start with a smaller scale, and build off of the 10-inch diameter ball. I covered the Styrofoam ball with dozens of pins that extruded exactly one centimeter off of the ball. I then glued them into place so that they wouldn't move back into the ball or further out of it. I did this so that I could use them as a guide when covering the ball with layers of plaster. I covered the whole ball with plaster until I was just barely over the guides. Once this was done, I had to wait a couple days for the plaster to dry enough to be sanded. (I found when I tried to sand the plaster before it was completely dry that it quickly gummed up my sand paper.) Once several days had passed, I was able to sand the plaster down better. Although the plaster continued to gum up my sand paper, it didn't do so as quickly as when the plaster wasn't dry enough.

I now have my Styrofoam ball covered in an even thickness of plaster, sanded down, and very smooth to the touch. Something I noticed when I had this all finished is that the ball became quite heavy. This made me think about how heavy my mold will be when I have the entire exterior completed and made with the plaster. This might just be an issue that I'll have to face. My next steps will be to create a mold to pour plaster into, that will create the actual mold that will create my concrete sphere.

This process will consist of creating a box 13 in x 13 in x 13 in. I will also have to add in supports the hold my plaster covered ball in the middle right where I need it to be. I also need to make this mold in such a way that it will be easy to take apart for when I need to get my plaster cube out. It will also have to be easy to put back together for its next use.

Journal Entry Eleven – Nov 13, 2015

This week I created my mold to make the mold that will create my concrete sphere. (This is some inception stuff). I made my 13 inch cubic box out of melamine board, because the sleek material on its surface is a natural and very good release agent. Perfect for when I will be removing my plaster cube.

Making this box required consideration of measurements, since I was using ¾ inch thick melamine board but I wanted the inside volume of my box to be 13 cubic inches. I strategically predrilled holes around the edges of the box to later screw it all together. I predrilled the holes so that when fastening the screws I didn't experience any blowouts in the board. I super-glued wooden dowels in the exact center of each side of the 13 inch cube to hold my plaster-covered ball directly in the middle. Once I had my box all screwed together, I sealed the edges with glue so that plaster wouldn't seep out of the edges of the mold. Additionally, I duck taped the outer edges to make them more secure.

Now that I had everything prepped and ready for my box, it was time to prep my plaster-covered ball to be submersed in plaster. In order for my ball to be removed after being submersed in plaster, I covered the ball in wax so that the plaster wouldn't stick to the plaster. Now it was time for the big moment.

I placed my wax-covered, plaster-covered Styrofoam ball in the center of my melamine box, supported by the wooden dowels. I then was ready to pour in the plaster. I discovered something as I began to do this. Mixing large amounts of plaster for the first time ever can sometimes prove difficult. It took me about eight mixes and pours of plaster to fill the entire box up. Each mix and pour got easier as I proceeded.

Now my box is filled with plaster to the brim. I waited for my final pour of plaster to get just dry enough to where I could fix up the top and make it nice and smooth. Now it is time to

wait for it to dry. I am supposed to wait a couple days. Waiting is one of the hardest parts of this project. All I want to do / need to do because of my time constraints is work on this project, but I always have to wait on something. Whether it is waiting for parts or materials to come in, or for something to cure, this project has taught me to have patience. This is a very valuable lesson. In this day and age we are used to getting what we want, when we want. Instant gratification does not exist in this project.

Journal Entry Twelve – Nov 20, 2015

This week I took my mold apart. Everything came apart very easily when I removed the screws. The melamine board worked very well as a form release. After I had everything apart and my plaster cube now exposed to the air, it was time to wait again for it to fully dry.

Once a couple days had passed it was time that I sawed it in half. Let me tell you – that was quite the work out. I precisely measured the cube to saw directly down the center. It took a while and a variety of saws to saw all the way through, but I got there. After I sawed it in half I created an opening at the top where I could pour the concrete in. This hole was also where the top opening in my concrete sphere would be.

This is approximately the third week that I've been working on this mold. If there's one thing that I've learned from this process it is that things of this creative nature always take much longer than you anticipate.

Journal Entry Thirteen – Nov 27, 2015

This week I did the first concrete pour in my new mold. The mold to make my 10-inch diameter hollow concrete sphere is open for business. I covered the Styrofoam ball with pins that protruded exactly one centimeter. After that I sprayed an even layer of Pam Cooking spray all over the mold. I then placed it inside the bottom half of the mold. I held the ball in place so that it didn't float up and began pouring concrete around the edges. When I filled the bottom half to almost the brim I then put the top half on. I strapped and clamped the top and bottom half of the mold together to keep it very secure. I then began pouring through the top hole to fill the top half of the mold. One problem I encountered with this is that the pins that I used were not strong enough to hold up against the concrete. Therefore, My Styrofoam ball began to float. Another issue I encountered is that I really couldn't see what was going inside my mold. I couldn't see where the concrete was properly flowing, where the concrete was not properly flowing, or where major air bubbles were.

After I did the best I could with my pour, all I could do was yet again wait. I waited about twenty-four hours for the concrete to cure. When I took apart the mold and pulled out the concrete sphere I found that it had a hole in the bottom and a large hole in the side. I hadn't evenly poured the concrete.

For this pour that I had used quick-drying cement. I think that while I was pouring, the cement cured faster that I could properly work it all around inside. For the next pour, I will use Portland cement, which is not as quick drying. I didn't have much success with this pour but I did learn a lot for my next pour.

After my concrete sphere had cured enough, I used acetone to dissolve the Styrofoam ball on the inside. I simply put the sphere on top of a bucket and poured acetone all around on the inside. The acetone melted the Styrofoam ball into a puddle of brittle plastic. After waiting a

couple hours, I could simply peel away the brittle plastic. Now I have my first attempt of creating my hollow concrete sphere finished. It doesn't look very pretty, but I learned a lot.

Journal Entry Fourteen – Dec 4, 2015

This week I did the second pour in my plaster mold. One thing I noticed about my mold after my first pour is that the plaster is an easy damageable material. The inside of my mold went from being a rather clean, smooth surface to being tainted and not smooth anymore, roughened by the concrete. I tried to smooth is out again with some sand paper, but could not salvage it all the way. This time for the pour I used stronger pins. I also used Portland cement so that the concrete wouldn't cure as quickly while I'm pouring. Mixing directions with the quick drying cement were very straightforward. Mixing directions with the Portland cement are not as straightforward. I mixed the cement as I thought it should be mixed. This time my pour went a little better. The bottom half turned out well but the top half not as well. The consistency of the concrete turned out a little odd as well when I took it out of the mold. I learned after talking with Evelyn that I had made the concrete too wet.

I need to learn more about mixing concrete and proper ratios of cement to water, as well as the proper ratio of aggregate to cement. The aggregate I will use will be sand.

Journal Entry Fifteen – Dec 11, 2015

This week I didn't get to do hardly as much for my project as I wanted to. While working on this project that is proving to take a much longer time than I thought it would, I am taking a full load of classes. Balancing everything has been hard. The patience that I mentioned before that is needed in this project, waiting for things like concrete to cure and materials to come in

the mail, has helped. While I am waiting on things related to this project, I can be working on things for other classes.

This week in particular is a big week for another class that I am taking, designing a drone that will monitor air quality. We had our final presentation to display our drone this week, so I had to focus all of my attention on that and set my honors project aside.

Journal Entry Sixteen – Dec 18, 2015

This week I had an end of semester review of my project. I invited my past industrial design professors to this review instead of my project committee. I did this so that I could get solely designer feedback on my project. I need to start thinking about every aspect of how my final form is going to look, as I will soon move into building another mold.

The rendering of what I wanted my final product to look like that I showed them had a large, approximately six inch opening at the top, and motifs around the whole sphere that are comparable to motifs found in native African cultures.

They gave me very good feedback on my design. Some things that they mentioned were to look into some kind of cover that can help the heating process, comparable to pool covers that help heat a pool. They told me that I should study and determine how they look as a group, and how the motifs might affect the function of the device (the perturbing bumps might affect the way it rolls). I also need to figure out exactly how much it might cost to manufacture one of these, because that is a very important question that I couldn't answer immediately. In terms of the mold making and casting of the sphere, I got critiques such as "start with a thinner wall thinkness, test it and then increase the thickness if needs be." Some additional good questions that I got were: Could this potentially be casted in the ground? How will it be delivered to users?

And lastly, what happens when they lose their usefulness? These are all questions that I need to work to answer as I move forward with my process.

Winter Break Dec 5, 2015 – Jan 11, 2016

I did not work on my project over winter break, as I had to work on completing my portfolio to be applying for jobs during this next and last semester.

Journal Entry Seventeen – Jan 15, 2016

Once back from winter break, I jumped right back into things. I couldn't waste any time at all. I needed to get going on things before work starts to build up in other classes.

This week I did a study to see how I could design the sphere to roll from side to side. This is an idea I am playing with. I am not positive what the exact weight of my finished sphere will be. What if it is too heavy and isn't easy to carry very much? Maybe the sphere will be something that stays at the home while the water is fetched with traditional vessels. The sphere will need to be moved to pour water out of it. It will need to ahve specifically designed surfaces to help the sphere roll when pouring the water out.

I rendered some surfaces on my sphere, 3D printed them, tested them and then identified the flaws of each. After identifying the flaws, I did more iterations, making each one better.

The most successful design had a wide surface on two opposing sides, that went all the way from the base to almost the edge of the opening. I included a protruding rim around the top

to act as a stopper for when the vessel has poured far enough. I also added a spout to help guide the water out in a concentrated fashion.

Journal Entry Eighteen – Jan 22, 2016

Last semester I had mostly unsuccessful pours from my mold yielding nothing “pretty”. This week it was time to hop back into the concrete pours. After mixing concrete so many times, I have learned a lot about what the right mixture and consistency of concrete looks like. This time I was going to get the consistency right.

I went through the usual steps of pouring, but this time I used wooden dowels for my spacers on the interior Styrofoam ball. I didn’t just cut them to about an inch in size and place them at the exact depth inside the Styrofoam ball this time. Instead I made the sticks approximately thirteen and a half centimeters long before I stuck them in the ball. I made them that length so that they could go in half way through the ball at twelve and a half centimeters, or five inches, and have just the desired spacer length of one centimeter left.

I went through the rest of my pouring checklist, which included having the inside of my mold covered in Pam, strap clamps ready, and having a pouring tool ready to move the concrete evenly throughout the mold when pouring. I poured the bottom half of the mold as best I could, and then strapped the top of the mold onto the bottom of the mold. I finished the pour from the opening at the top. While doing this pour, I was still experiencing significant issues with the ball moving around. The sticks still weren’t quite capable of keeping it stable throughout the pour. When I was just about finished with the pour, I had to create some wedges to keep the Styrofoam ball from being pushed to the top of the mold. I fixed the issue as best I could at the moment. Then it let it sit for twenty-four hours.

Journal Entry Nineteen – Jan 29, 2016

I took my last pour out of the mold at the beginning of this week, or at least attempted to. My pour got stuck in the top part of the mold. I think what happened is that the plaster absorbed some of the Pam, and then the concrete attached at certain places to the plaster. I tried to chisel out around the edges, thinking that might make a difference, but it did not. I ended up have to saw the top half of the mold that was stuck to my pour in half to get it off.

This was a semi-successful pour. It did not have any holes in it or large air bubbles, However it was very thin at the top around the opening. I had progressed to having a semi-successful pour, and my mold in three pieces instead of two.

I worked on putting the top of my mold back together into one piece for the rest of the week. In order to do this, I strapped a clamp around both pieces to hold them together, and then filled in holes, gaps, and cracks with Sculpy. I used Sculpy because it is a non-drying clay that wouldn't be permanent, just in case I ever wanted to remove or add to my mold.

Journal Entry Twenty – Feb 5, 2016

This week I was determined to get the best pour that I could. To do this, it required me to change my method of pouring. This time I tried something new. Before, my method was to pour most of the bottom portion, put the top half of the mold on, and then pour the rest from the top opening, all in one pour. This time I placed the Styrofoam ball in its desired position, and strapped it down using a clamp so that while I was pouring the bottom half, it wouldn't move or float. In addition, I let the bottom half cure for a couple hours so that the concrete was cured enough that the Styrofoam ball wouldn't move out of its position, but still wet enough that freshly poured concrete could adhere to it.

Before doing my second pour with the top half of the mold on, I texturizes the cured concrete in the bottom half of the mold. I used different tools and poked deep holes around the edges. I did this so that the fresh concrete I would be pouring would flow into those holes. That would help the two poured halves stay together.

After finishing this very smooth pour, I let it cure for a couple of hours and then cleaned up the edges around the top opening of the vessel. This purpose of the cleaning was to make the top come out as smooth and clean looking as possible. After a few touch-ups, it was time to wait, for twenty-four hours.

My pouring process has now turned into about a forty-eight hour plus event. I've come to realize that each pour is like running a marathon. I'm profusely sweating by the end of each pour. Then, when finished pouring, much patience is required to let it cure. Ideally you'd like to pull it out immediately and see how it turned out. Was it a success or failure?! All the waiting leads to so much anticipation. A solid twenty-four hours of anticipating the outcome.

When I took my pour out, it was the best pour I had achieved during the entire time working on this project! I was ecstatic. The walls of the vessel that came out were a perfect, even thickness. With just a few issues of small air bubbles, it was the closest I had ever gotten to perfection.

Journal Entry Twenty-One – Feb 12, 2016

Now that I have nailed down my pouring process and learned how to achieve the perfect pour, I can experiment with my mold and add to it to change the exterior. It took me a lot of time this week to decide how I wanted the exterior to be constructed in this new version.

At first, I had experimented with different traditional African patterns for aesthetics. I included two rims around the whole vessel that were 3 inches apart, which is also the average hand width. I did this so that the rims could help stabilize the hands when holding the vessel in air. After consulting about this design with Evelyn, who is all-knowing about concrete, she mentioned to me that the rims would not be reliable and would not hold up over time. After hearing her comments, I thought about different ways taht I could make my vessels easier to grip and pick up.

I ended up with a scallop design that would be consistent around the whole vessel, very much the style of a scallop clam. This kind of design would make it easy for each bump or scallop to grip around.

I decided to implement this design by 3D printing shapes that were two halves of a half of an elongated oval. I will be adding these to my mold. These will be the negative space, or the space between each scallop. I printed these so that I could get an even thickness and area for each space between the scallops.

Journal Entry Twenty-Two – Feb 19, 2016

This week I finished the new interior of my mold and did another pour. I consistently placed my 3D printed inserts throughout the top and bottom halves of my mold. I secured the molds using a normal drying clay this time, instead of Sculpy, because I had a hard time getting the Sculpy to stick to the plaster. I really liked using the regular clay, because I could flatten it out very nicely and make the whole interior of the mold super-smooth.

I ran into a problem at the end. The clay began to dry, and when it did it started to crack in many places and shrink. This is something I did not account for, as I was not familiar enough

with the material I was using. To combat this problem, I had to keep the clay consistently damp using damp paper towels and a plastic sheet to cover it.

As a result of this issue, I ended up having to pour my mold with the clay inside still damp. Ideally, I would have liked to have poured with the clay bone-dry, but if I had let it dry to that point it would have shrunk, cracked, and fallen to pieces. However pouring with the clay still damp did not prove to be an issue.

I went through my usual process of pouring. The pour went very smoothly until the very end. I used a smaller Styrofoam ball in the center so that there would be no risk of holes in my final form. When I added to the mold, I decreased the diameter of the inside of my mold. If I had gone with my traditional ten inch Styrofoam ball, it might have been too big to achieve my desired wall thickness of my vessel. As a result of this I had a hard time getting the concrete to keep its shape at the top. The concrete wanted to slump and settle, but I wanted it to stay up. To combat this I had to jerry-rig some walls to keep the concrete from settling at the top. By using the smaller Styrofoam ball on the inside, I had increased the mass and in turn the weight of the resulting vessel. This was not important to me though. What was important to me was representing a new diverse exterior of my form to show the possibilities of the forms structure and aesthetics.

When I took my form out of the mold it was perfect! Another success! This form was much heavier than my last successful form, but they both exist for two different reasons. This second was to show how the form can be diverse in shape, and the previous to represent desired thickness of a functioning form.

Journal Entry Twenty-Three – Feb 26, 2016

Once I finished another successful pour last week I realized that I had to start getting ready for my exhibit that was happening in exactly one month, and that I only had three weeks to create it because I would be losing one week to spring break. It was time to switch gears this week.

To prepare for my exhibit I had to create digital, graphically pleasing, informational posters that would lay out every stage of my product. In the end, I need to have posters that visually represented who my audience is, the issues they are facing with energy resources and water resources, my product, how my product works with the water sanitation process, what my product would look like in use, and possible manufacturing and dissemination processes I could use to produce and distribute my product. It was time to move from the concrete lab to the computer lab.

I started creating a poster to represent who my target audience is for my product. Since my inspiration for this project came from visiting less-fortunate people living in rural areas of South Africa, I decided to make them my target audience. However, this does not mean that my product could not be easily implemented in another similar region.

Creating this poster required very intensive research from credible sites. It also required me to be creative in deciding how to visually represent statistical data. It took me the last half of the week to create this poster.

Journal Entry Twenty-Four – Mar 4, 2016

This week was a very bad week…I started the week by beginning on my next poster to represent current energy resources being used, different water resources that exist in rural areas of Africa, and issues that exist with the water from those resources.

When working on this poster something happened with my computer and flash drive. Suddenly when I plugged my flash drive in, I couldn't access anything on it. I was getting a message saying that my flash drive was corrupt. I had suddenly lost everything that was on my flash drive. I tried for hours with help from a friend to get the files back and recover them but I had no such luck.

For the rest of the week I remade what I had already created once before. Although this was not what I wanted to be doing, it was in some ways okay. Remaking the posters that I lost, I was able to make them faster and better. I think that the new poster I made turned out much better than the first. Maybe losing the first version of the poster was a blessing in disguise.

Spring Break Mar 5 – Mar 12, 2016

I did not work on my project during Spring Break.

Journal Entry Twenty-Six – Mar 18, 2016

This week it was time to put the pedal to the metal. On my flight back from an ever so wonderful spring break, I slowly realized the massive amount of work I had waiting for me upon my arrival back at school. I had a total of six more posters to create before my exhibit.

I don't have much to say about this week. I spent a lot of time staring at a computer. Doing this graphic design work is a much duller activity than anything I'd be doing in the concrete lab. I'm looking forward to being finished with this.

Journal Entry Twenty-Seven – Mar 25, 2016

Tomorrow is my Exhibit. I have all of my posters printed and hung up in the gallery space. My posters turned out very nicely after many long hours in the computer lab. I have all of my molds and forms collected and ready to be exhibited. I have my documentation photos printed and ready to hang. I invited my teachers, my family, my friends at school, and my friends from home. They all will be coming to see what I have been working on for a full year now. This is a very exciting time.

One of the hardest parts of getting ready for this exhibit was coming to terms with the fact that my project is not finished. Throughout the past year my project has been very research-heavy. And as Albert Einstein once said, "If we knew what it was we were doing, it would not be called research, would it?" I had no way of foreseeing the way this project was going to progress. When I began this project I pictured having a complete and well-rounded product in the end. Instead, I took successes and failures (mostly failures) as they came. I learned and grew throughout the entire project.

My project is not finished, but the first steps into developing my concrete water pasteurization device have been taken. These first steps were necessary steps, and without them I wouldn't be where I am or have all of the knowledge and experiences I gained throughout these first steps. I will continue on with this project. I know now what needs to happen to take more steps in developing my project.

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