PROJECT 2 FINAL REPORT

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Team #3

Abstract
The objective of this project was to design an alternative filter press to help reduce cost and prove to be more efficient. We decided to design a model that best fits a mid-sized family in Africa. First, we conducted some background research on previous water filtration methods and the conditions that we needed to improve in order for it to be beneficial to a mid-sized family in Africa. Using this research, we generated several possible concepts for our design. Then, after testing each individual concept, we picked our final design. Next, we revised our designs using pairwise comparison charts.

1.0 Introduction

Our team has been put in charge of redesigning an alternative filter press to help reduce cost of manufacturing and maintenance. We have conducted research on our product and on the terrain and climate of Africa and came to the conclusion that our product will need to be very heat resistant and use simple materials that can be found in nature to maintain the filter. Using this, we determined which features our filter press should exhibit.

Our time management for this project proved to be very effective. At the very beginning, we conducted a management meeting and estimated the length of each task and came up with a calendar of events. To do this we used a project management template which stated each object and how long it would take to complete. By doing this we know what we were supposed to do each and every week. Other tools that we used for our project include the internet for patent searches and prices for our product.

1.1 Initial Problem Statement

Our initial problem statement is to design an alternative filter press that is made out of cost friendly material and is easy to find materials in nature to maintain the filter. The product must be easy to assemble, durable, and have a low cost over its lifetime.

2.0 Customer Needs Assessment

Unfortunately, we are not able to conduct a survey for our customer needs because the customers that we are targeting are people in a third world country that we are not able to communicate with. However, we based our customer needs off of the basic needs of humans for water consumption and what we feel would be most important when providing water filtration systems to people in Africa, given the climate and general living conditions.

2.1 Weighting of Customer Needs

The purpose of weighting our customer needs is so we can develop our product in a way that caters to the more important needs than the ones that people can do without. With the amount of money we are trying to save it is impossible to make everything perfect but if we rank the needs in order of importance we can better choose the features that will be more satisfying to the customers. This helps us when it comes to concept generation and design

selection. We want a product that fits the most important needs of our customers so that people are willing to invest in it and the product benefits the customer.

Table 1. Initial Customer Needs List Obtained from Team Focus Group and Individual Interviews/Surveys

Cost
Availability of materials
Small environmental footprint
Lifetime of filters
Water purity
Ease of operation
Lightweight
Quantity of water filtered

This table lists the things that we felt were most important to address in our design. They are not weighted or are in any particular order; however, it sets the path for what we will focus on in our design.

Table 2. Hierarchal Customer Needs List Obtained from Focus Group and Individual Interviews

1 Cost
1.1 Availability of materials
2 Small environmental footprint
2.1 Lifetime of filters
3 Water purity
4 Ease of operation
4.1 Lightweight
4.2 Quantity of water filtered

This table groups the customer needs into categories that are easier to focus on. This helps us order and rank them so

we can focus more easily on the important needs when it comes time to generate concepts and choose our final design.

	Cost	Envir. Footprint	Water purity	Ease of operation	Total	Weighting
Cost	**1.00**	5.00	7.00	9.00	22.00	0.59
Envir. Footprint	0.20	**1.00**	5.00	3.00	9.20	0.25
Water purity	0.14	0.20	**1.00**	3.00	4.34	0.12
Ease of operation	0.11	0.33	0.33	**1.00**	1.77	0.05

Figure 1. AHP Pairwise Comparison Chart to Determine Weighting for Main Objective Categories

	Availability of materials	Lifetime of filters	Light-weight	Quantity of water filtered	Total	Weighting
Availab-ility of material	**1.00**	5.00	7.00	9.00	22.00	0.59
Lifetime of filters	0.20	**1.00**	5.00	3.00	9.20	0.25
Light-weight	0.14	0.20	**1.00**	3.00	4.34	0.12
Quantity of water filtered	0.11	0.33	0.33	**1.00**	1.77	0.05

Figure 2. AHP Pairwise Comparision Chart to Determine Weighting of User Friendly Sub-Objectives

Figure 1 and 2 compare each of the customer needs aspects to each other so we can see which one is more

important. After we determine their final rankings we take these values and put them into Table 3 so that we have a clear list of what is the most important problem to solve to the problems that do not need immediate attention.

Table 3. Weighted Hierarchal Customer Needs List Obtained from Focus Group and Individual Interviews

1 Cost (0.59)
    1.2 Availability of materials
2 Small environmental footprint (0.25)
    1.2 Lifetime of filters
3 Water purity (0.12)
4 Ease of operation (0.05)
4.1 Lightweight
4.2 Quantity of water filtered

3.0 Revised Problem Statement

Since we didn't perform a customer needs survey, most of our goals in the initial problem statement will be repeated here. Again, our objective was to design an alternative filter press that is made out of cheap and easy to find materials. The product must be easy to assemble and be readily available. Using our research as a guide, we decided that we need to focus on areas such as the material that the filter press is made of, the availability of the components that make up the materials that are used for the filtering, and the simplicity of assembly.

4.0 External Search

We began our report with the external search, in which we researched the background information needed to understand the project. The aspects that were included in our online research were patent search, product archaeology, and benchmarking. A patent search makes sure that we are formulating our own ideas and using things that have proven to be efficient. Product archaeology researches past products and we can learn from them whether they have positive or negative aspects. And finally, benchmarking compares three products to one another to see which features work the best.

4.2 Patent Search

Table 4. Art-Function Matrix for Charcoal Water Filter

FUNCTION		**ART**			
	Straw	filter #2	Filter #3	Filter #4	Filter #5
Sediment Filter	US 4995976				
Container		US 8256632	US 8256633	US 8256634	
Size			US 8256633		

Amount Filtered		US 8256632			US 8257599

4.3 Product Archaeology

In this section, we analyzed various products that were similar to our product. The most basic one we found was first in the chart and consists of a cylinder filled with layers of gravel and sand into which the water would be poured. Overall, most of the samples we found all included a filtering system that utilized layers of sediment to filter the water. As we continued our search, we began to find more intricate systems in which several sizes of sediments were used. For example, sand was the finest sediment, and the pebbles, and the rocks. Several filters also used charcoal which we decided to add to our final design.

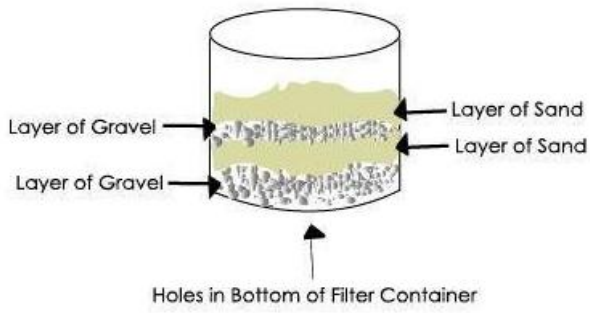

Fig. 3.1

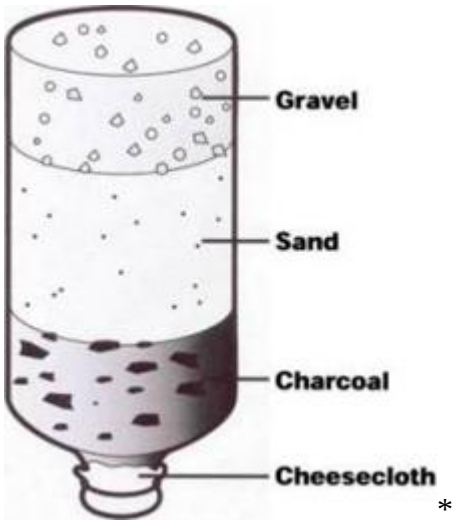

*Fig. 3.2

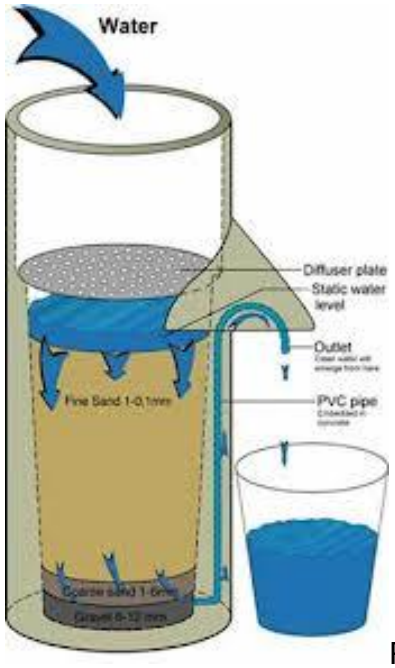

Fig. 3.3

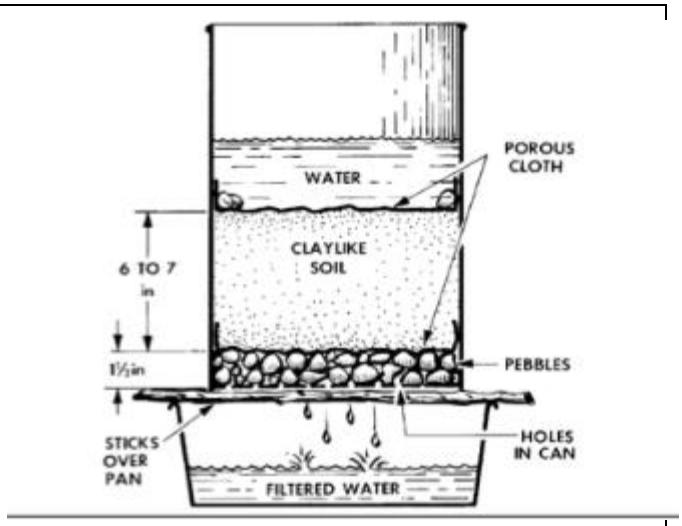

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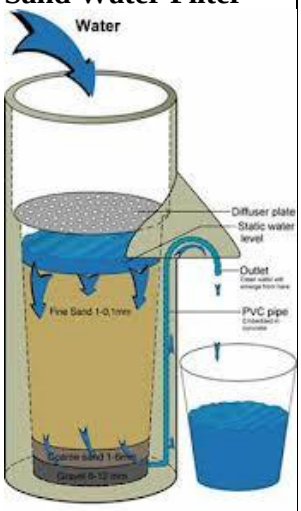
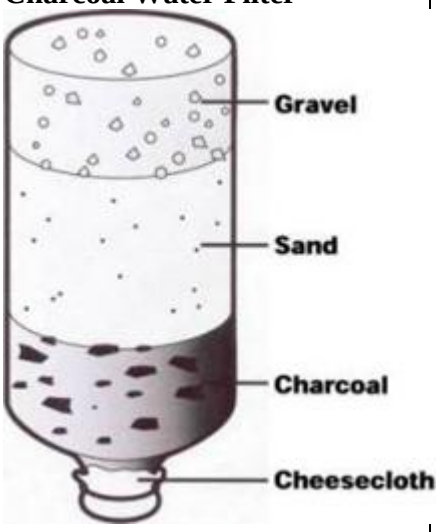
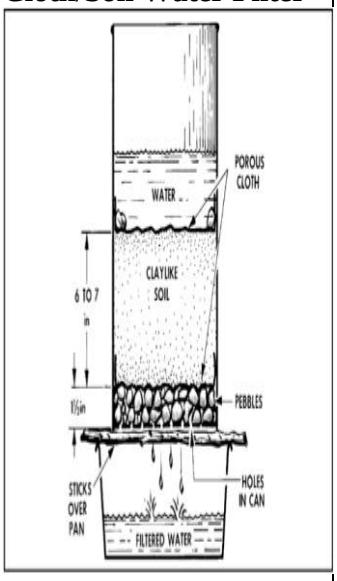
Fig. 3.4

4.4. Benchmarking

In this table, we will compare three different water filters and will rate them on a five point scale: 1- strongly disagree, 2- disagree, 3- neutral, 4- agree, 5- strongly agree. For each cell rating, we will compare features of the three products to what we expect in our features for our finished product. For example, a rating of 1 means that the quality of the feature in the given product is very poor to the quality we are expecting in our final product. Whereas, a rating of 5 means that the quality of the feature meets the standards of the quality of the feature in our product.

Table 5. Benchmarking of Four Products

Feature	**Sand Water Filter**	**Charcoal Water Filter**	**Cloth/Soil Water Filter**
	 Fig 4.1	 Fig 4.2	 Fig 4.3
Cost	5	5	4
Materials (made out of)	3	5	3
Easy assembly	3	5	2

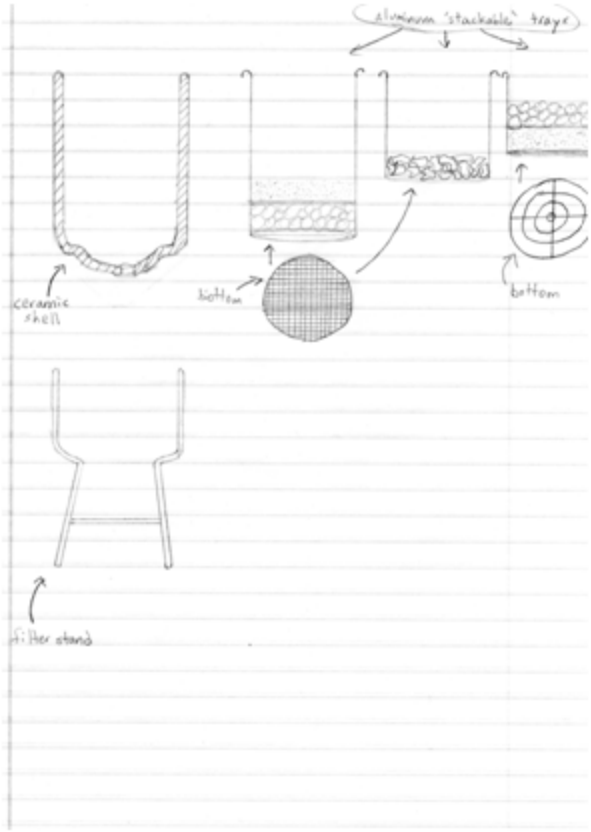
Ease of finding materials that are used in the filtering process	5	5	2
Effectiveness	4	4	3

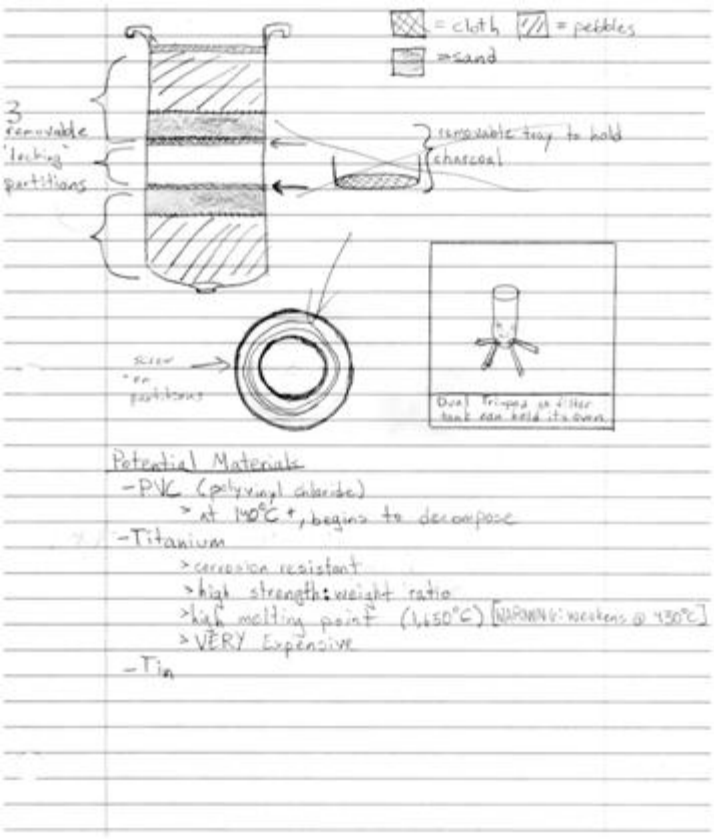
4.5 Design Target

Using the results of the external search, we decided that we still need to look for the same features we initially wanted to use in our product. Also, we learned about different types of water filters and used these analyses to generate concepts, which we will discuss in our next section.

5.0 Concept Generation

We generated ideas for several functional groups necessary for this design project. The functional groups include body type, method for renewing used materials, and type of holder stand. We generated these ideas in a somewhat irregular fashion, as we did not follow the typical process of generating based on functional group. We generated complete product ideas and then separated each into the functional groups and chose which functional groups from each model would combine to make the best product.





Potential Materials

- PVC (polyvinyl chloride)
  - > at 140°C +, begins to decompose
- Titanium
  - > corrosion resistant
  - > high strength:weight ratio
  - > high melting point (1,650°C) [WARNING: weakens @ 430°C]
  - > VERY Expensive
- Tin

Fig 5.1
Fig 5.2

6. Concept Selection

Discuss and provide the Pugh Charts (refer to pages 186-191 of course text) that were used to decide which combination of concepts from the morphological chart best met the design teams customer needs. This design concept becomes the final design that is developed further.

Table 6.1. Pugh Chart 1

	Strength	Weight	Manufacturability	Cost	Total	Rank
	0.3	0.2	0.2	0.3		
Iteration 1						
ceramic pot	0	0	0	0	0	1
titanium pot	-1	1	-1	-1	-0.6	2
tube pot	-1	1	-1	-1	-0.6	2
Iteration 2						
ceramic pot	1	-1	1	1	0.6	1
titanium pot	0	0	0	0	0	2
tube pot	-1	1	-1	1	0	2
Iteration 3						
ceramic pot	1	-1	1	1	0.6	1
titanium pot	1	-1	-1	-1	-0.4	3
tube pot	0	0	0	0	0	2

Table 6.2. Pugh Chart 2

	Strength	Balance	Ease of Use	Durability	Total	Rank
	0.3	0.2	0.2	0.3		
Iteration 1						
Dual Tripod	0	0	0	0	0	1
Simple Stand	-1	-1	1	1	0	1
Octastand	-1	-1	1	-1	-0.6	2
Iteration 2						
Dual Tripod	1	1	-1	-1	0	1
Simple Stand	0	0	0	0	0	1
Octastand	-1	1	-1	-1	-0.6	2
Iteration 3						
Dual Tripod	1	-1	-1	-1	-0.4	3
Simple Stand	1	1	1	1	1	1
Octastand	0	0	0	0	0	2

Table 6.3. Pugh Chart 3

	Strength	Effectiveness	Ease of Use	Durability	Total	Rank
	0.3	0.3	0.2	0.2		
Iteration 1						
Stackable Trays	0	0	0	0	0	2
Removable Tray	-1	-1	1	-1	-0.6	3
Screw On Partitions	1	0	-1	1	0.3	**1**
Iteration 2						
Stackable Trays	1	1	1	1	1	**1**
Removable Tray	0	0	0	0	0	3
Screw On Partitions	1	0	-1	1	0.3	2
Iteration 3						
Stackable Trays	1	1	1	0	0.8	**1**
Removable Tray	-1	0	-1	-1	-0.7	3
Screw On Partitions	0	0	0	0	0	2

7.0 Concept Improvement through Creativity Methods

In this section, we will explain our design problems and how we solved these problems in our final design. We did this by using the TRIZ method and compared the values which we received from the process.

Design Problem 1:
Strength vs Temperature
Design Principles: 30, 10, 40

Design Problem 2:
Durability of Stationary Object vs Weight of Stationary Object
Design Principles: 6, 27, 19, 16

Design Problem 3:
Strength vs Weight of Stationary Object
Design Principles: 40, 26, 27, 1

Table 6. Design Solutions

Feature to Improve	Contradiction	Principles	Design Solutions

Strength	Temperature	1. Flexible film or thin membranes 2. Prior action 3. Composite materials	1. Instead of plastic used ceramics.
Durability	Weight	1. Universality 2. Inexpensive short life 3. Periodic action 4. Partial, overdone or excessive action	2. Removed the middle tray to decrease the weight.
Strength	Weight	1. Composite materials 2. Copying 3. Inexpensive short life 4. Segmentation	3. Decided to use stainless steel trays instead of aluminum.

In our initial design, we had 3 trays, but after some research and brainstorming, we decided to incorporate only 2 trays in our final design. Also, we initially wanted our shell for the water filter to be made out of plastic. In the end, the plastic shell would not work because it would melt in the hot temperatures. Initially, we wanted to have aluminum trays, but we decided it would not work because the aluminum would not be able to support the load.

In this section provide the explanation of the functional decomposition of the design improvement problem with 'black-box' model(s). More information and examples can be found on pages 145-152 of the course text. Then using at least two specific creativity methods, generate further ideas to improve the preliminary design concept selected. One of the selected methods should be TRIZ; document the technical contradictions, and ideas generated.

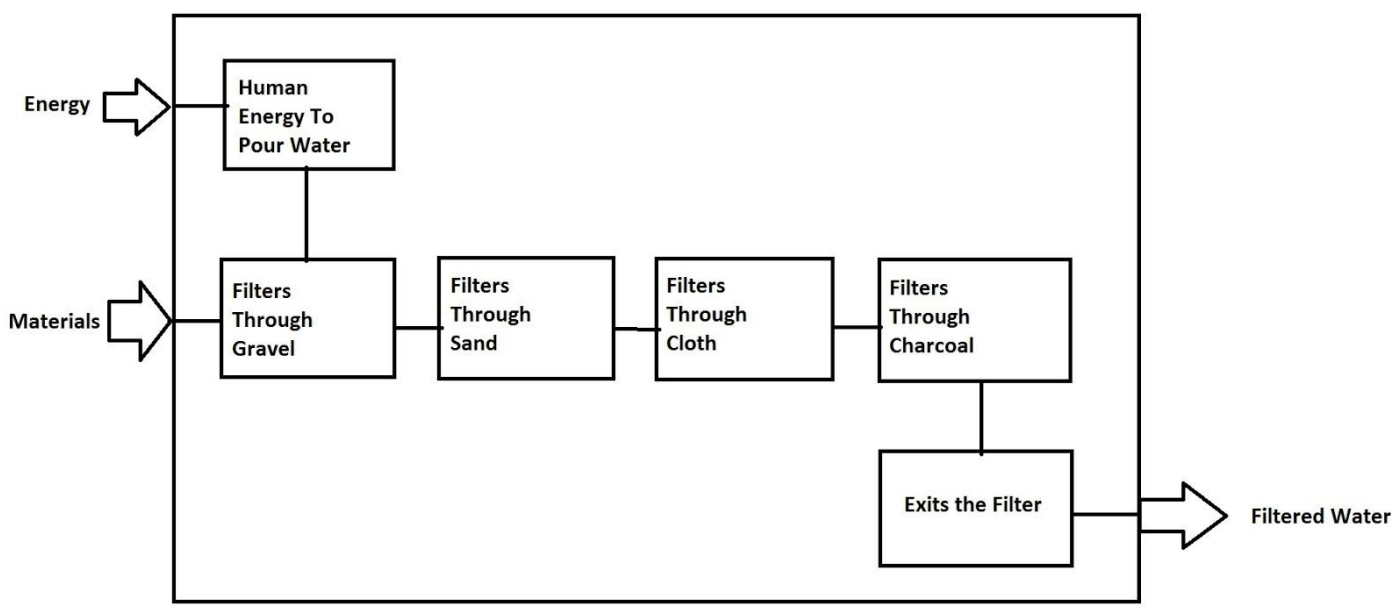
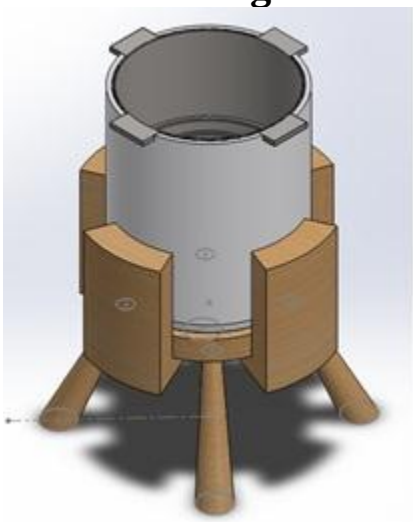


Figure 7.1 Black Box

Materials	Stand	Trays	Container
Ceramic	Box Stand	1 tray	Cylinder
Plastic	Tri Stand	2 trays	Box
Stainless Steel	Quad Stand	3 trays	

Figure 7.2 Morphological chart

8.0 Final Design



Our final design is comprised of 4 removable parts. There is a stand to hold up the weight of the filter and protect it from falling/breaking. The shell of the filter is the outermost layer made up of ceramic. It is designed to withstand the brutal heat that is common in Africa without affecting the water inside. The middle layer of the filter is the first stainless steel tray. It is designed to be easily removable in order to change the filtering activated charcoal when needed. The innermost layer of the filter is the second stainless steel tray. It is designed to hold the layer of sand as well as the layer of gravel while remaining easily removable. With all of these parts combined, the resulting water filter is effective in its purification of water and can easily be cleaned in case of contamination or ineffectiveness due to aging materials.

8.1 Materials and material selection

Using the discussed methods, including a decision table, show how materials and components were selected that best meet the team's needs.

8.2 List of Materials

The following tables describe the amount, prices, and provider of the materials for our water filter.

Table 6. List of required materials and components

Qty	Description	Catalog Number	Vendor	Total Cost
1	304 stainless steel	8989K33	McMaster Carr	33.40
1	Terracotta Clay	5432J78	Michael's Art Supply	15.99
4	2x4	5478M93	Home Depot	7.97
	Total Cost			**$81.27**

Table 7. Contact information for suppliers of required Materials

McMaster Carr Supply Co.	Michael's Art Supply
473 Ridge Rd.	302 East High Street
Dayton, NJ 08810	Barrington, NJ 08007
(732) 329-3200	(856) 457-9970
	FAX: (856) 457-9970
Home Depot	
235 New Castle Road	
Bridgewater, NY	
610-343-5467	

8.3 Cost & Life Cycle Cost

The majority of our product is made from ceramic so although it may not be the most cost efficient material it is the only material that can survive in the hot, African climate and maintain a long lifetime. Also, the center trays are constructed from stainless steel, which is expensive, but will not disrupt the quality of the water being filtered and will not rust, which extends the lifetime. Our process does come with a cost, however, once it is completed there is no cost to maintain the filter because all of the materials used to change the filter mechanism can be found in nature thus having no cost.

9.0 How Does It Work & Conclusions

Overall, we feel as if the project design was successful. It meets all of the basic customer needs that we felt were the most important and it is effective when it comes to filtering the water. Since it is a product for a family in a third world country, the fact that all of the materials needed to maintain the product can be found in nature proves to be extremely beneficial to the consumer and will be useful for the time to come.

References (Times New Roman, 16, Bold)

Note: That for the author-date system, references are listed in alphabetical order.

Fig. 3.2; http://my-countrycomforts.blogspot.com/2011/07/pop-bottle-water-filter.html

http://web.mit.edu/watsan/tech_hwts_particle_ceramicfilters.html