THE *VHEMBE* FILTER: A PRODUCT FOR RURAL SOUTH AFRICA

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Introduction

According to Chochinov (2010:6), '[f]rom Victor Papanek's *Design for the real world* to John Thackara's *In the bubble*, from Buckminster Fuller's *World game* to Bruce Mau's *Massive change*, there has been a perennial desire to drive home the imperative of design for social good.' The first aim of this article is therefore to document a South African design project that focuses on social good and the impact the outcome could offer a very large segment of society through improved water quality.[1] The second aim is to illustrate how a user-centred industrial design methodology can be used to develop an existing product become better suited to its users, and to show how this methodology can be applied to product development intended for rural settings. The specific product used in this case study is the existing *Filtron* water filter and the resultant improved design is called the *Vhembe* water filter. Martin Bolton[2] undertook the development of the *Vhembe* filter in fulfilment of a Master's degree in industrial design at the University of Johannesburg from 2007-2009. The Master's project formed part of a larger collaborative research project that aimed to investigate whether an intervention that improves water quality would measurably improve the health of people using the intervention. This larger project,[3] a collaboration between the University of Venda (UniVen) and the University of Johannesburg (UJ), was headed by Professor Natasha Potgieter and funded by the Water Research Commission through UniVen with research conducted in approximately 25 rural villages in the Vhembe district of the Limpopo Province, South Africa.

In the early stages of the collaborative project, it became evident to the project leaders that a qualified industrial designer's knowledge and expertise would add value to their research. In June 2006 Professor Paul Jagals, the project's UJ co-ordinator, approached Angus Campbell, lecturer in the Department of Industrial Design at UJ, to discuss the opportunity for an MTech Industrial Design student to participate in the project. Bolton was then incorporated into the larger project in order to focus on understanding the users, their needs and requirements with a specific focus on product use and acceptance. This approach helped to lead the development of an unknown product into something more suited to the intended users within rural South Africa.

A brief overview of the background of the existing filter design and the preparative steps, which took place prior to the field intervention of the existing filter, is firstly provided. The article then unpacks the data gathered from users of the filter and the interpretation of that data into an improved filter design. It further illustrates how placing the user at the centre of the design process results in a final product better suited, and therefore more sustainable, to its users.

Figure 1: Original ceramic *Potpaz* filter, circa 1981.

Figures 2 & 3: Two *Potpaz* filter variations developed after 1998.

Filter background

The original filter, named the *Potpaz* filter, is a low-cost, low-tech, colloidal-silver[4] enhanced gravity-fed ceramic home water treatment device for use in rural households whose water at point-of-use[5] is contaminated. It supplies enough water for drinking and food preparation for one household of approximately four people and has been proven to effectively remove 99.99 per cent of protozoa by mechanical processes (Lantagne, Mintz & Quick 2008:25). The *Potpaz* filter was designed in 1981 by Dr Fernando Mazariegos, a researcher from the Central American Industrial Research Institute (Figure 1). The concept was to develop a water filter that was affordable and that could be manufactured by the communities using it, thus empowering the 'poorest of the poor' (Potters for Peace 2006a) to provide their own potable water. In 1998, Potters for Peace[6] (PFP) began assisting in the worldwide production of the *Potpaz* filter (Figures 2, 3). This filter was developed with input from South American countries, such as Guatemala and Ecuador, and is currently manufactured by various companies across the world[7] and then branded as their own. The exact brand of filter that was imported for use in the Vhembe research project was the *Filtron* water filter (Figures 4, 5), manufactured by *Ceramica Tamakloe* (2006) in Ghana.

The assembled *Filtron* filter comprises a large 40-litre moulded plastic receptacle into which a ceramic pot

Figure 4: Assembled *Filtron* filter with covering lid in place.

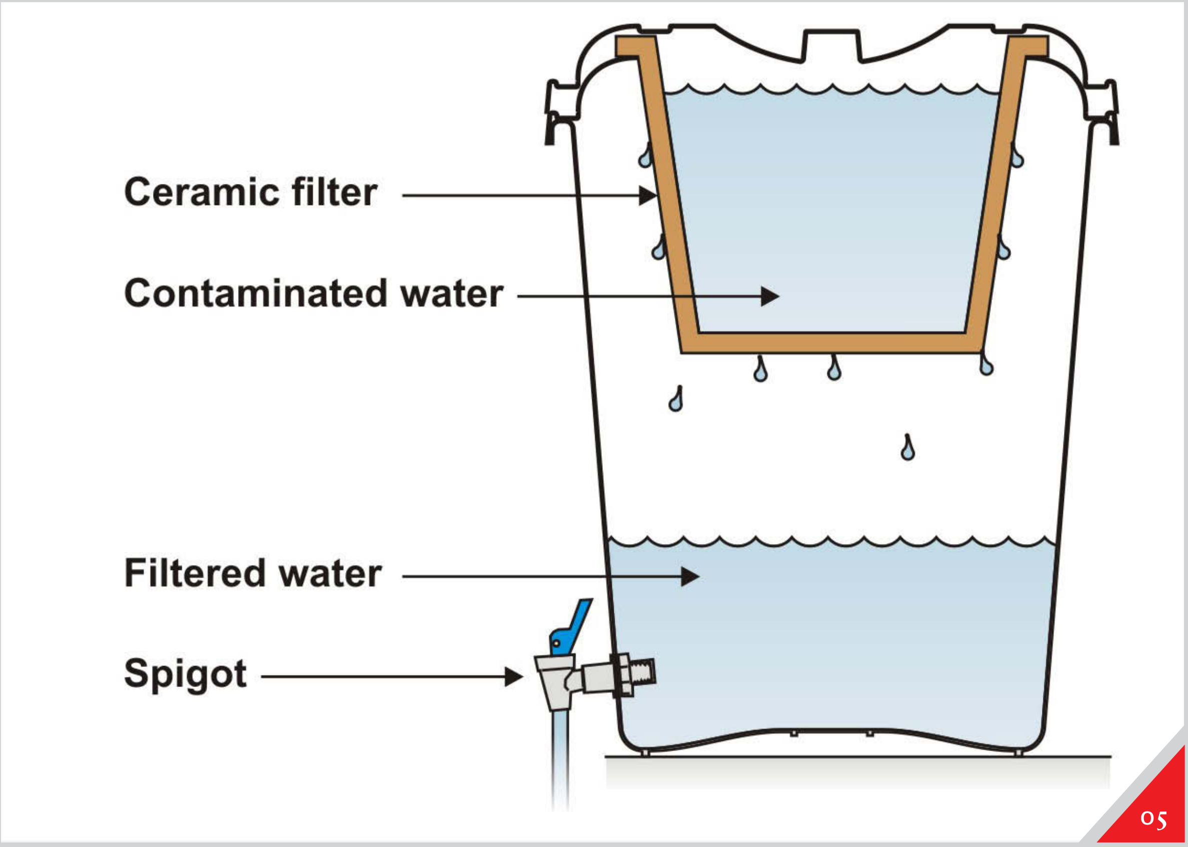

Figure 5: Operation of the *Filtron* filter.

shaped filter element is suspended (Figure 4). This ceramic filter is held in place by a plastic retaining ring that fits onto the top rim of the receptacle. The design also includes a loose plastic covering lid and a sub-assembled spigot on the lower side of the receptacle.

The *Filtron* filter operates by removing the covering lid, the ceramic filter element is then filled with contaminated water (Figure 5). The water saturates the ceramic filter element and slowly filters through the ceramic pores at a rate of between 1.5 to 2.5 litres per hour, provided the filter is kept full. The filter needs the weight of the unfiltered water in the element to create sufficient pressure to push the water through the pores. Finally, the water filtering through the filter element drips into the receptacle where it is stored, ready for consumption.

Since the *Potpaz* was developed in South America, which differs from South Africa both environmentally and socially, the design may operate less effectively in South African rural environments. For this reason, the *Potpaz* may need to be adapted for South African use, but before undertaking any changes, the *Filtron* filter was implemented as is and its effectiveness and receptiveness assessed in order to document any shortfalls in the design. If there were problems, highlighted through the users' assessment, the redesign of the filter from an industrial design and user-centred standpoint should lead to the development of a filter more suited to its use in South Africa. The redesigned filter could also possibly be better suited to its use in South America since the American scientists who developed the *Potpaz* filter did so without consulting industrial designers and with no documented process of user-evaluation.

Suitability of the *Filtron* filter for implementation in South Africa

The *Potpaz's* success in South America prompted its choice for implementation in South Africa where 'the magnitude of the task of providing people without sustainable access to improved water supply with the ultimate option, piped water in the near future has initiated investigations into alternative technologies' (Conroy, Du Preez, Genthe, Gundry, Moyo, Mutisi, Ndamba, Potgieter & Wright 2008:1). For this reason 'point-of-use interventions are fast becoming the preferred method for providing improved water quality' (Conroy *et al* 2008:2). The *Potpaz* filter is a scientifically proven point-of-use intervention (Lantagne *et al* 2008:25). In addition, the plastic components in the *Filtron* filter are strong, lightweight, stackable and easy to transport. In other words, it is durable and relatively easy to roll-out for user testing.

User-centred design methodology

For any product to be accepted by its users it needs to suit the function for which it was intended as well as its users' understanding of that function. In a typical industrial design process, an initial list of design requirements is formulated before any development work commences. These design requirements are criteria the product should satisfy in order to fulfil its intended function successfully. If designers get these criteria wrong or skew the design problem through their own mis/preconceptions, then the chances that the product will not fulfil its intended function effectively are considerably increased. Similarly, if the product functions effectively but is not accepted by its intended users, which is a common problem in design solutions rolled out to users by far removed designers,[8] the users will most likely not use the product for a prolonged period of time, eventually rendering it obsolete. The process that was followed in formulating the list of design requirements for the envisaged *Vhembe* filter had to rely heavily on the outcomes of the assessment of the data gathered from user field-testing the existing *Filtron* filters. It was therefore important to develop a methodology that encompassed both the industrial design process and the rural users from the onset of the research project.

The initial research for the redesign of the *Filtron* filter required Bolton to glean information from the users of the filter. Since Bolton comes from a significantly different background to the members of the rural communities for whom he was designing, it was difficult for him to understand the circumstances, requirements and preferences of the users. Identified individuals in the communities in their own home environment were approached on a one-to-one basis using the *Filtron* filter as a starting point (the data gathering process is explained below). Green and Jordan (1999:13) highlight the value of the product designer being directly involved in data generation: '... the data in design terms is less likely to be a corrupt process when the designer is using self-generated data, and the efficiency with which the data is incorporated into the design process is enhanced immeasurably if the designer is intimately involved.'

Being intimately involved in data gathering through interviewing the users and observing the environment where the filter units were kept, afforded Bolton the opportunity to be immersed in the needs, requirements and preferences of the intended rural users regarding the use of the device. Their input was invaluable in demonstrating where the existing filter functioned effectively and identifying existing problems. As a qualified industrial designer, Bolton possesses the technical knowledge and capabilities to solve problems of product development, manufacture and distribution which the rural users were unable to do. Bolton is not, however, the intended user of the filter. Placing the user at the centre of the design process with the industrial designer sorting and organising data into meaningful requirements is typically referred to as user-centred design.

Ryan Fowler (2005:23) states that an 'industrial design methodology that does not acknowledge the values of potential product users is unlikely to be able to address accurately the needs of these users, and widespread product acceptance is then unlikely to be achieved'. User-centred design methodology originated in Donald Norman's research laboratory at the University of California San Diego in the 1980s (Abras, Maloney-Krichmar & Preece 2004:1). Abras *et al* (2004:3-4) state that

> Norman's work stressed the need to fully explore the needs and desires of the users and the intended uses of the product. The need to involve actual users, often in the environment in which they would use the product being designed, was a natural evolution in the field of user-centered design. Users became a central part of the development process. Their involvement lead to more effective, efficient and safer products and contributed to the acceptance and success of products.

In *The design of everyday things*, Norman (1990:2) writes that well-designed objects are easy to interpret and understand, as they contain visible clues to their operation. It is therefore important for the designer to have an understanding of either what the user would consider beneficial or a hindrance to usability. The best way to do this is to include the user's feedback from interaction with a similar product or development models to inform the design process of the improved product. It is not only important to get user feedback during the design process but design theorist Victor Margolin (2002:28) believes that designers are also obligated

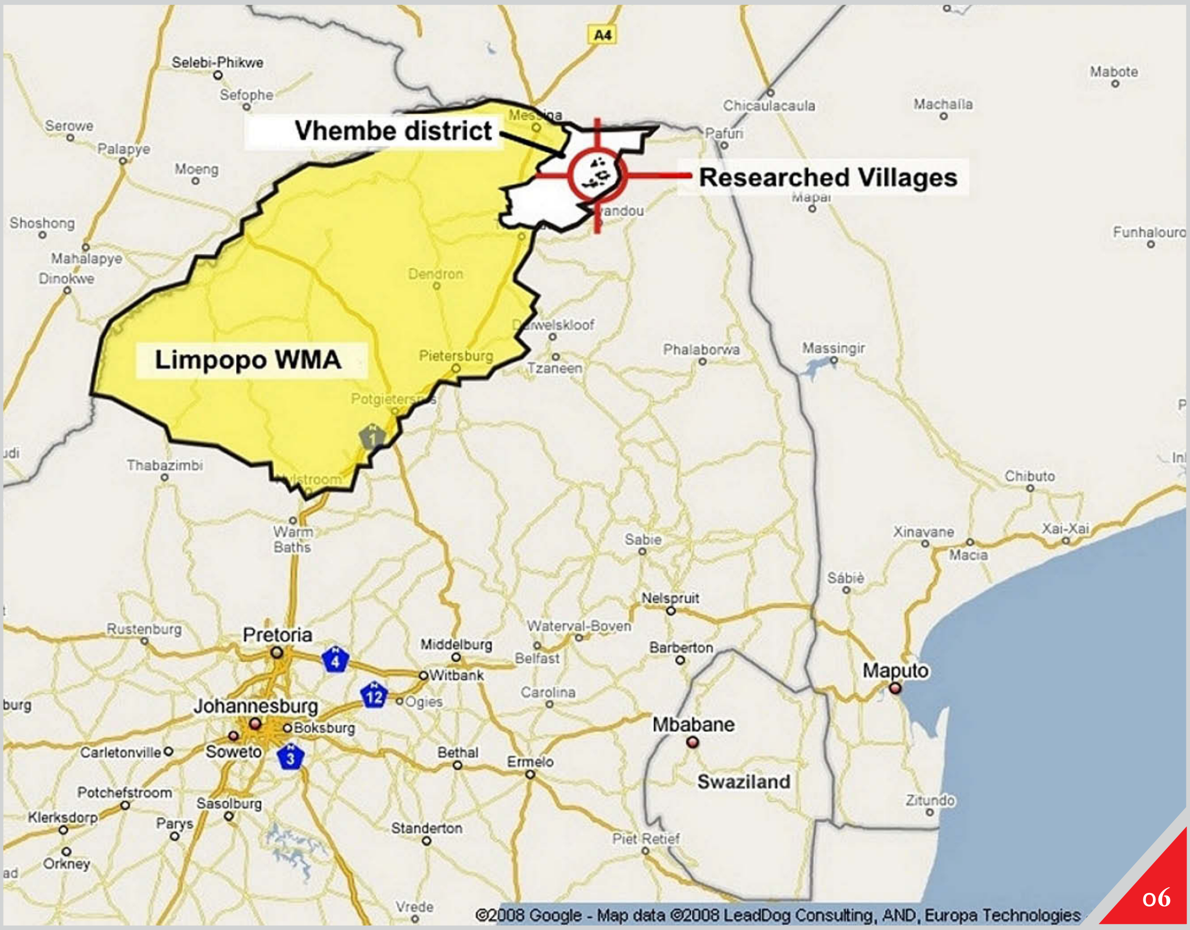

Figure 6: Village locations, Vhembe district, Limpopo Province.

to evaluate their final designed products in actual situations to test their effectiveness.

Filtron implementation, data gathering and field research

Figure 7: The *Filtron* filter at implementation

The first step in undertaking a user-centred redesign of the *Filtron* filter was to survey an appropriate sample of rural users. *Filtron* filters were rolled out to 65 households, spread throughout 15 villages within the Vhembe district of the Limpopo province, South Africa (Figure 6). Households were randomly selected based on distribution across the research area and located by using a handheld GPS to log the co-ordinates of each household. Each household was coded in relation to its

Figure 8: Venda-speaking interviewer conducting an interview with a *Filtron* user.

specific GPS co-ordinates, which were used as a reference to keep track of all data gathered at that location. At implementation, users were educated on how to use and maintain (clean) the filter by a Venda-speaking[9] translator/field assistant. After they had used the filter for a minimum of two months, which was deemed an appropriate time to get the users accustomed to the filter, data gathering and field research took place.

Three data gathering methods were used to gather data at each household: personal interviews with filter users were undertaken with assistance from Venda-speaking translators/field assistants; observation schedules were completed by Bolton; and photographs were taken to provide visual evidence of the filter in situ within the household. The aim was to provide as objective as possible an observation of the filter within the households and the receptiveness of the *Filtron* filter from the users' viewpoint. The users who took it upon themselves to maintain the filter in each of the 65 households were chosen as the interviewees by Bolton and the Venda speaking interviewers. These users provided their informed consent to participate in the interview and observations (including photographs) that took approximately one hour per household. This meant that in total Bolton spent at least 65 hours with the users in the various environments where the filter was used.

The questionnaire administered by the Venda speaking interviewer followed a set schedule (Figure 8). This questionnaire was translated from English to Venda by translators at the University of Venda and vice versa for the responses. This data provided the personal view-

Analysis of placement

In which room is the Filtron filter kept?
On what surface is the Filtron filter placed?
Does this surface form part of the surrounding area or has it been specifically constructed for the filter?
How does one retrieve water from filter? (stoop, kneel, bend, stand up straight)
How high is the placement surface above the floor?
If you could have the Filtron filter placed at any height, what height do you think would be ideal?

Analysis of design aspects

Has the filter ever been knocked over?
Have you experienced any stability problems?
How do you lift the lid?
Do you use a specific container, or not?
How do you hold the container and open the tap?
Are any parts of the filter broken or damaged? If so, what parts?
Where is the Filtron filter located in relation to stored water?
Have any alterations been made to the Filtron filter?

Analysis of use

Is there a difference in the taste of the filtered water?
Do you like the taste of filtered water?
How many times do you fill the filter per day?
How do you fill the ceramic filter? (scooping from drum, pouring from large bottle,etc.)
Is the Filtron filter in operation?
Are there any insects underneath the lid?
Do you experience any problems when filling the filter?
Do you experience any problems or irritations when cleaning the ceramic filter?
Does the filter's tap leak water?
Does the filter's tap supply water fast enough?
Does the filter provide sufficient water for everyone in your family?
Does the Filtron filter look clean?
What can be changed on the filter to make it easier to use? (comments by community member)

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Figure 9: The focus areas and key points of the questionnaire and observation schedule.

points of the users regarding their preference and perception of the product.

The questionnaire and observation schedule included topics regarding three focus areas: 'placement', 'design aspects' and 'use'. 'Placement' refers to where the *Filtron* filter is kept in the households: in what room, on what surface, at what height, as well as its proximity to the water source in the households. This allowed for an understanding of the immediate environment in which the users keep and use the filter. 'Design aspects' refers to the *Filtron* as a product and focuses on elements of the filter that operated well, as well as where possible improvements could be made. Questions were framed to identify any problems or irritations with stability, ergonomics, filling procedures and to identify areas where the filter had been altered in any way by the users. 'Use' referred to the use and cleaning of the filter; problems encountered and points of satisfaction. These questions documented whether or not the users noticed a taste difference between filtered and unfiltered water, and which they preferred. Filter care was also documented with regard to how often the filter was cleaned and if the filter was still operational at the time of the interview.

Within each of the 'placement', 'design aspects' and 'use' sections of data gathered there were respectively six, eight and thirteen different key points that were identified (Figure 9). With each of these points, it was possible to list, from answers given by the users and observations taken by Bolton, what design improvements could be made to better suit the filter to the users or the environment in which it was used.

In addition to the questionnaire and observation schedule, photographs were taken to document the condition of the filter after several months of use. This included where it was kept, on what it was kept, cleanliness, damage, and alterations, to name a few. In the data analysis, it was possible to compile a broad list of successful aspects of the *Filtron* filter as well as areas where improvement was possible. The ability to sort this data was grounded in the industrial designer's understanding of product use, quality, ergonomics and manufacture. The different data gathering methods allowed for a spread of influence, informing the assessment of the *Filtron* filter and decreased the possibility of a biased viewpoint from either the designer or the user.

In order to illustrate how the data gathered from the 65 field interviews assisted in the development of the improved design, one of the key points within the placement focus area is discussed as an example in the following section.

Placement surface

Within the placement focus area, the surface on which the filter was placed in each household provided useful clues. Owing to the assembly and position of the tap on the *Filtron* filter, it was necessary for it to rest on an existing surface to allow for a container to fit under the spigot for water retrieval. Through the data gathering, it soon became evident that many households did not have an unused surface on which the filter could be placed. In more than half the households, the filter stood on pedestals constructed of loosely packed concrete or clay bricks (Figures 10, 11).

Other placement surfaces included plastic crates, plastic buckets, a wooden tree stump and a paint tin, to name a few. This was a problem since these improvised pedestals tended to be unstable and without them, the filter would not function correctly.

The specific design requirements formulated from the placement surface key point were as follows:

- The filter either should be used free standing, or must be able to be operated without relying on existing surfaces in the households. This would eliminate the need to find an existing placement surface in each household.
- If the filter relies on a stand, this stand must be provided as a portion of the filter unit/or incorporated into the filter.
- The filter must be stable on the uneven ground within the households.
- The filter should be placed at a suitable height to allow the user to retrieve filtered water comfortably from the filter.
- The filter should be placed at a suitable height to allow the user to fill the filter element comfortably, by using various water storage containers.

The design requirements for each of the key points were collated and graded according to three priorities: high, medium and low (Figure 12). From this prioritised list, Bolton was then able to explore solutions by means of concept sketching and then development models. This process attempted to incorporate all the design requirements into one design, the *Vhembe* filter. Of

Figure 10: A loosely stacked brick pedestal.

Figure 11: Makeshift pedestal made of bricks wrapped in newspaper.

High Priority	
Suitable to be placed in any household room.	Yes
Useable whilst on the floor.	Yes
Free-standing, not relying on a surface of placement.	Yes
Incorporated stand, if needed.	Yes
A balance between ease of filling and dispensing.	Yes
Spigot between 200mm and 800mm above floor.	Yes
Unit must be stable.	Yes
Comfortable interfaces where holding and lifting takes place.	Yes
Must include a dust cover.	Yes
Covering lid to be easy to use.	Yes
Covering lid to be removable for filling.	Yes
Covering lid to prevent insect access.	Yes
No gap between filter and receptacle.	Yes
Spigot able to fill varying containers, small teacup to 2l container.	Yes
Must include picograms and text for explanation of use, care and cleaning.	Yes
Filter receptacle should hold 16l of water.	Yes
Ease of assembly and disassembly (no tools required).	Yes
Receptacle to be clear or translucent.	Yes
All components to be stackable.	Yes
Manufactured with a good cost-to-benefit ratio.	Yes
Material characteristics: food grade, hard wearing, easy to clean.	Yes
Job creation: filter element manufactured by local potters and materials.	Yes
Filter to consist of as few components as possible.	Yes
Components to have hygienically associated colours.	Yes
Consideration for post-use functionality.	Yes
Medium Priority	
Ergonomic and comfortable incorporated handle in filter lid.	Yes
Visual water level indicator.	Yes
Spigot able to be permanently and temporarily opened.	Yes
Minimal dirt traps.	Yes
Low Priority	
Receptacle base angled towards spigot.	Yes
Spigot at lowest point on receptacle.	Yes
In moulded pictogram on receptacle explaining spigot function.	No
Stand for filter element to rest on, during cleaning.	Yes
Mechanism to hold container for filling.	Yes

Figure 12: Table indicating design requirements met by the *Vhembe* filter. 12

the varied solutions to the observed problems, many were not viable due to increased manufacturing costs, an inability to stack (making shipping and distribution difficult), or complexity of filter assembly, to name a few.

To return to the example of the surface placement key point, the following aspects of the Vhembe filter satisfy the design requirements (Figure 12):

- The filter can stand directly on an existing flat surface in the household, in the stand (provided

Figure 13: Final *Vhembe* filter rendering showing the two stand placement variations.

Figure 14: Final *Vhembe* filter rendering showing component stackability.

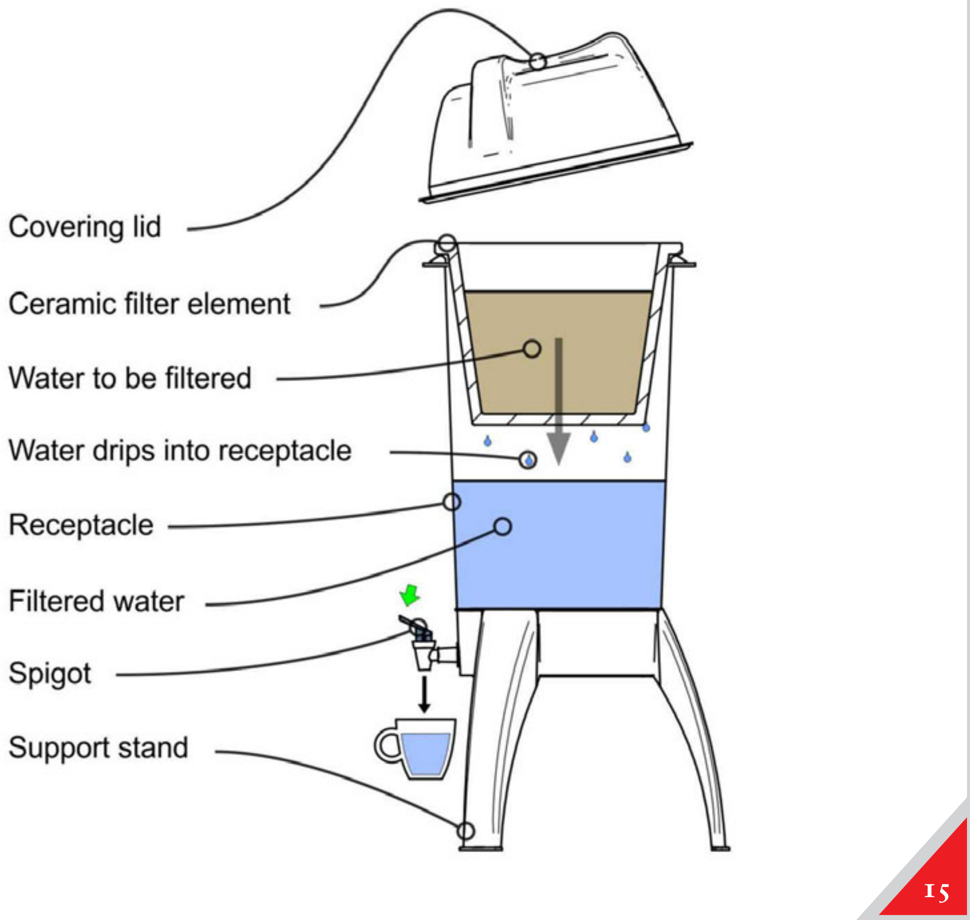

Figure 15: Diagram illustrating the *Vhembe* filter's operation.

with the filter), or suspended (hung) from above. This gives a wide variety of placement options to the user (Figure 13).

- While utilising the supplied stand, the filter rests at a suitable height, allowing the user to retrieve water without having to bend over uncomfortably, as well as low enough to the floor to allow the user to fill the filter element comfortably by using various water storage containers.
- It has three legs allowing it to rest firmly on the floor, even if the floor is uneven. This makes the improved filter more stable than the existing *Filtron* filter (Figure 13).

Figure 12 indicates that all high and medium priority design requirements and most of the low priority design requirements were met in the *Vhembe* filter design by Bolton. Through a process of user feedback and industrial design, the majority of areas of concern in the *Filtron* filter were resolved in the *Vhembe* filter with the result that a final working prototype could be produced (Figures 15, 16).

Conclusion

A final step is required to satisfy the user-centred industrial design methodology. In order to completely validate the *Vhembe* filter design, the filter needs to be batch produced using soft tooling[10] for a second round of implementation, user testing and user feedback. This has not yet been undertaken owing to financial constraints;


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Figure 16: Photograph of the final *Vhembe* filter prototype.

however Bolton is in the process of sourcing funding for this final phase. Even without this final validation the concept satisfies many of the design requirements that the Filtron filter did not. Some of the most salient design improvements to the *Filtron* included in the *Vhembe* filter are better filter placement; limiting insect access to the filter element; improved ergonomics; and improved ease of use of the filter with regard to filling and retrieving water and maintenance (Figure 12). The *Vhembe* filter design is based extensively on the users' input that was gathered after regular use of the *Filtron* filter. The industrial designer's pre/misconceptions were minimised by focusing the design process around the product's intended users and by spending extensive time in the environment in which the new design would be used. By means of the application of a user-centred industrial design methodology the outcome is a functional, affordable, easily manufactured and easily distributed product (Figure 14), suited to high production numbers and low unit costs. The filter could prove better suited to solving contaminated water problems within similar living conditions than those offered by filter alternatives in other rural areas in Southern Africa, Africa, and possibly other developing nations around the world. This could potentially improve the living standards of many people by providing them with an effective, usable product suited to their living environment. The methodology utilised within this project can be applied in the development of many other products for rural communities, yielding products that meet the needs of intended users, fulfil their intended functions effectively and with a greater chance of uptake by intended users.

NOTES

1 The Smithsonian Institution (2007:145) held an exhibition titled *Design for the Other 90%* in 2007 at the Cooper-Hewitt, National Design Museum; in their resultant publication they state: 'Of the world's total population of 6.5 billion, close to 5.8 billion people, or 90%, have little or no access to most of the products and services many of us take for granted; in fact, nearly half do not have regular access to food, clean water, or shelter.'

2 MTech dissertation title: Design and development of an improved low-cost ceramic water filter based on the existing *Potpaz* home water treatment device for use within rural households of the Vhembe region. Department of Industrial Design, Faculty of Art, Design and Architecture, University of Johannesburg 2006 - 2009.

3 Barnard, TG, Bolton, M, Brown, J, Hunter, P, Mieta, SIK, Netsikweta, L, Ntema, V, Omar, K, Potgieter, N & Sobsey, MD. 2009. Improving health-related microbial quality of drinking water at the point of use with ceramic Potters for Peace filters: effects on rural people living with HIV/AIDS. Unpublished manuscript.

4 Colloidal silver is an effective antibacterial water treating agent in the form of tiny silver particles suspended in liquid. It is a disinfectant that prevents bacterial growth in the ceramic filter and assists in inactivating the bacteria in the filter (Lantagne, Mintz & Quick 2008:25).

5 Households do not have piped water into their houses, they have to collect and transport water from communal water collection points in the form of communal tap standpipes and borehole pumps. A constant problem is created when the water is consumed within the rural households, owing to the fact that its health-related microbial quality has deteriorated to the point where it is 'unsafe' to

drink (Conroy, Du Preez, Gundry, Moyo, Potgieter & Wright 2006:7).

6 Potters For Peace is a US based non-profit organisation founded in Nicaragua in 1986, comprising a network of potters, educators, technicians, supporters, and volunteers who work with clay artisans in Central America and worldwide on ceramic water purification projects.

7 These countries include Cuba, El Salvador, Guatemala, Cambodia, Colombia, Nicaragua, Dominican Republic, Sri Lanka, West Darfur/Sudan, India, Indonesia, Kenya, Ghana, Tanzania, Yemen and Benin (Potters For Peace 2006b).

8 In Travis's (2009: 8) exploration of effective designers, '... some of their clients thought they were good designers. Many of the people who tried to use their designs thought otherwise.'

9 The Venda language, also known as Tshivenda or Luvenda, is a Bantu language and an official language of South Africa, spoken predominantly within the Limpopo province of South Africa.

10 Batch production typically refers to the production of less than 1 000 units. In order to plastic injection mould even one unit, tools (moulds) still need to be produced. By producing the tools from aluminium (soft tooling) instead of tool steel, costs can be greatly reduced, but this is only viable for a small run of units since the tools are soft and wear very rapidly.

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