WATER FILTRATION FOR PEOPLE IN THE FAVELAS

A DESIGN CHALLENGE IN TERMS OF COVID19



Deliverable B

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Context Study

Introduction

This context study aims to provide insight towards answering the research question "How can proper healthcare be ensured in Brazilian *favelas*, with a focus on sustainable solutions?". For the coming academic semester, this challenge will be tackled with the intent of providing a solution for the problem at hand. Brazil is a country with a plethora of socio-economic problems, therefore there is an urgent need for a solution which can improve the vulnerable population proper access to healthcare. The COVID-19 pandemic further amplified the pre-existing issues. The second and third phases of the project also include a contextual discussion. This context study lays out the research conducted and reveals the ethical implications that are raised when a new design is placed upon a society.

1. Design Challenge

The path chosen for this design challenge is providing a sustainable source of clean water for the residents of the *favelas*.

Before designing a product, it is essential to understand the stakeholders, their context and the concepts regarding responsible design. These considerations can be summarized in the lemniscate on the left. All these different parts will be discussed one by one.

2. Worldwide context

Water

97.5% of the water resources on planet earth is saltwater, the remaining 2.5% is fresh water (UNESCO, 2014). Two-thirds of the resources for freshwater is found in glaciers

and permanent ice covers, the remaining fresh water is made of surface and underground water. This means that not even 1% of earth's water resources can be used by humans (UNESCO 2009). Furthermore, over two million people die due to waterborne diseases. Epidemiological studies have conducted research on developing countries in Africa, Asia and South America. They have come to the conclusion that there are around four billion cases of diarrheal disease per year, this results in 2.5 million deaths a year and is the reason for 17% of deaths among children younger than 5 years (Black et al., 2010). Another study in Yaounde, Cameroon has shown a diarrhea prevalence of 14.4% linked to contaminated drinking water (Yongsi, 2010).

3. Brazil in context

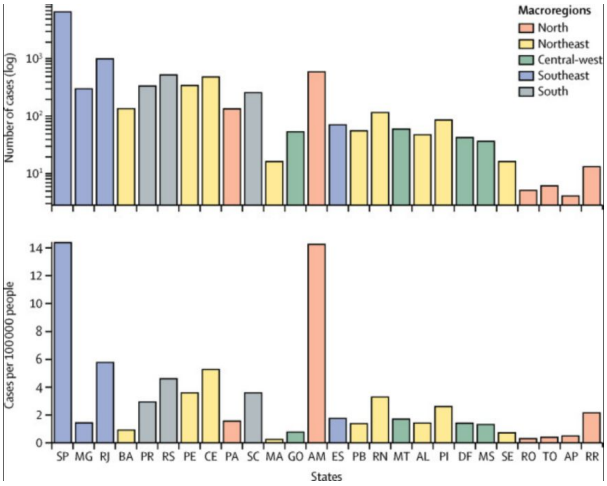
History of Brazilian population

The first populace relevant for Brazilian heritage and history is the Native Americans, divided into many distinct ethnic groups. After this initial phase, the next main wave of cultural influences was brought from Africa, dragged on the backs of slaves forced out of their home and into Brazil. They contributed in many aspects such as musicality and the religious syncretism present in Brazilian society. Finally, the last waves that added to Brazil's cultural blend were brought by the immigrants originating mostly from Europe. Modern Brazilian culture is formed by the different cultures of the Native Americans, Africans and European, mostly Portuguese (Hofstede, 2010).

The Brazilian Institute of Geography and Statistics (IBGE) classifies the population of Brazil into five different categories, the five categories are based on ethnicity: *Indigeno* (Indigenous), *Preto* (black), *Branco* (white), *Amarelo* (East Asian) and *Pardo* (mixed ethnic ancestries).

There are some interesting facts about the different categories when it comes to health care. *Pardo* and *Preto* admitted to the hospital with COVID-19 have much higher rates than that of *Branco* (Baqui, 2020). It is stated that mortality to COVID-19 has increased in socioeconomically northern regions in comparison to southern regions (Baqui, 2020). The mortality risk was especially very high in Rio de Janeiro when it is compared to its

neighbouring states. The higher risk of deaths within *Pardo* and *Preto* is caused by the fact that they have less economic stability on average, this means that they are less likely to be able to stay at home. Furthermore, the north and northeast states are more vulnerable to the pandemic (Martins et al., 2020).



The amount of cases and deaths in the different states of Brazil. https://www.sciencedirect.com/science/article/pii/S2214109X20302850

Brazil in times of COVID-19

Within COVID-19 cases and deaths worldwide, Brazil ranks second (Watson, 2020). Since Brazil has such a diverse population and fragile political and economic situation, it is of great importance that the socioeconomic and ethnic health inequities are understood. The impact of the COVID-19 pandemic in Brazil is discussed.

It is known that COVID-19 has had a worldwide strain on health care. Brazilians have limited access to testing and social security (Souza et al., 2020).

Due to these difficulties in testing, assessing the growth of the pandemic becomes harder. Similarly limited access to social security can result in a large portion of society not engaging in social distancing. In Brazil, these difficulties have been further complicated due to the unstable federal government, and as a result of this, supporting measures such as physical distancing and attempting to downplay the gravity of the pandemic have failed (Souza, 2020) This has been stated in the media: “Brazil: Bolsonaro’s defiance of distancing criticized by the health minister.”(The Guardian, 2020). From June 23, 2020 onwards, Brazil ranks second worldwide in total number of COVID-19 cases and deaths, with a high estimated rate of transmission (Cereda et al., 2020).

5. People in the favelas

The design must focus on the inhabitants of *favelas*, considered the slums in Brazil's big cities. These people cannot afford private healthcare, and the public healthcare system is lacking proper resources, infrastructure and hospital beds. This lacking system got even worse in times of COVID-19 (Staff, 2020).

Living conditions

Residents of *favela* areas live mostly in informal houses. This means they do not own the land or are registered (Veysseyre, 2014). These houses are crammed together with narrow streets and small passages and most of the time crowded with families, which inherently makes social distancing a very distant reality (UNIC Rio, 2020).

The inhabitants of *favelas* do not have sufficient access to clean water, causing an increased risk in a pandemic (Novo, 2020). Since the buildings are not registered, the government cannot legally provide sanitation and sewerage utility. This has partly been solved by providing a central site in a community to which residents can manually connect to the grid. (Novo, 2020). However, many areas need to connect to neighbouring areas due to a lack of infrastructure. Many problems emerge in this interplay, there are many problems with maintenance, shut offs, and the water is not considered very clean. (Novo, 2020) Due to a lack of sanitation and hygiene, the spread of the pandemic is amplified.

In the *favelas*, the access of electricity and internet depends on the installation and use of *gatos. Gatos* is the Portuguese word for stealing the internet and electricity (Omari, 2015). They tap it illegally from the cables and poles. The *favelas*, just as the rest of the world, have embraced the internet as part of their daily lives, as it is now considered a vital part of democracy (Omari, 2015). The government has taken measures to improve these facilities and provide universal access (Peteranderl, 2013).

In a time parallel to another pandemic, of fake news and misinformation, their access to the internet does not provide clear insight on what

to do in a crisis. 33% of the people living in the *favelas* think the pandemic is in its final state, has already ended, or never existed (Maggiola, 2020).

The income of the inhabitants of *favelas* comes mostly from informal work. Informal work is not registered and is mostly cash without tax. This ranges from selling merchandise on the streets to repairing houses. There are also many people who do informal jobs next to their normal job, as the minimum-wage does not provide good enough life-support for families (Neri, 2016). Most of these jobs require interaction with others, rely on tourism and cannot be performed from home. This means that during the pandemic, especially if there during a lockdown or social isolation, many people have no income. According to a study from Data *favela*, 80% of the people living in the favelas are living on less than half of their normal income due to the pandemic and 35% have lost everything (Maggiola, 2020). Residents get their food and income from street markets, which requires them to go outside and be in contact with other people.

Social structure

The people living in the *favelas* share a strong community feeling, and have strong relationships with many neighbors (Milliati Rebello, n.d.). However, they are less friendly to outsiders and people they don't know or recognize, excluding social workers.

The family structure is of extreme importance in Brazilian culture. Usually there is a strong male figure who provides for the house and family and makes important decisions (Wilding, 2010). This is decisive for the implementation of engineered solutions, as they are ultimately in charge of deciding what is best for their family.

The *favelas* are unsafe and the people living there experience a lot of violence in their daily lives. Gangs conflicts, street fights, brutal police forces and robberies, and many other forms of violence are experienced daily. (Gonzalez, 2018). People in the *favelas* do not die from bullets, gun-toting traffickers or police violence (Larkins, 2015).

At this moment, Brazil faces a lot of challenges, and people do not feel secure and cared for by the government. There are many protests and conflicts (Thousands protest, 2020), because people feel desperate, as there seems to be no hope of rescue or help.

Urgent needs

The things that would improve the life of people in *favelas* the most at the moment are: healthcare, education and basic sanitation (Larkins, 2015). These three concepts will be elaborated upon.

Firstly, many people in the *favelas* tend to have lower rates of literacy, higher dropout rates and age-grade disparities (Khanna, 2016). The barriers that provide the stakeholders with low education include poverty and a high population density (Education in, 2020). In addition to this, there is a vast inequality between the rich and the poor due to a debt crisis, rising wage inequality and high inflation (Khanna, 2016). People in the *favelas* remain trapped within the cycle of poverty. This again contributes to the massive population density in urban areas. Child workers earn money for their households instead of going to school, because more that 50 percent of the people who live in the *favelas* are unemployed (Khanna, 2016). In addition to this, violence and trauma contribute to the child's inability to learn. Even though public education in Brazil is free, a lack of resources causes the inability to support students outside the classroom (Thelwell, 2020). All of this creates an inhospitable environment for any real education.

This is a structural problem and not a technological one. Therefore, in this project

Secondly, the stakeholders need basic healthcare. They die from chronic uncared diabetes and a poor diet. Secondly, the inability to access emergency medical services causes people to die from a stroke or heart attack. The concept of basic healthcare embodies the demand for redirected funds to be injected in the healthcare system, as an effort to improve the general infrastructure and expand preventive medicine. They are in need of a state-of-art hospital, since the nearest emergency room is overcrowded, there are long waits for treatment and the walls are crumbling (Barbassa, 2016). In the *favelas* they believe that these things have to be provided by the state, but sadly, this is not possible. Due to the fact that the universal, public system, Sistema Unico de Saude (SUS) is understaffed and underfunded (underfunding and, 2020), especially in urban areas (Larkins, 2015). This is also a structural problem where the government has the responsibility.

Thirdly, the people in the favelas need access to clean water. As mentioned before, their

water supply is not consistent. It is not clean. Access to clean water allows people in the favelas to stay home and isolate more easily. Furthermore, they can wash their hands more often and with cleaner water, further reducing the spread of viruses. This will lighten the load on the public healthcare system and decrease the infection rate drastically.

Secondary Stakeholders

To fully grasp the process of design integration and implementation, it is important to consider secondary stakeholders. The secondary stakeholders directly affect relationships with the primary stakeholders (Stakeholder Analysis, 2018).

One very important secondary stakeholder for this design is the Potters for Peace Water Filter Project. The project intends to make safe drinking water available. They act through offering workshops teaching locals how to produce ceramic filters, ensuring that any materials used are found locally. Their

The latter urgent need will be the focus of our design challenge. A technological solution could improve the access to clean water to all households.

aim is to create filters that are low-tech and low-cost (PottersforPeace, 2019). The filters from Potters for Peace are produced at 50 independent factories in over 30 countries. The filters are ‘the highest-rated products for rural point-of-use water treatment (Smart Disinfection Solutions, 2010).

Other important secondary stakeholders are manufacturers of any design parts that are not found easily at the primary stakeholders’ surroundings. The Brazilian company Cerâmica Stéfani also uses ceramic layers for filtration, with handmade terracotta containers (Cerâmica Stéfani, 2017).

5. Responsible Design

There are many things engineers need to consider when designing targeted solutions. The context and stakeholders have been addressed in the previous chapters. To further distinguish the roles of the context, the stakeholders and our design and the ways they interact, this chapter will delve deeper into the concepts of mediation, capabilities, appropriateness and sustainability. These concepts will complete the lemniscate.

5.1 Mediations

To analyse the role of technologies in society, Verbeek proposed the theory of technological mediation as a framework. Analyzing the roles of technology in human existence and society is vital when designing a product, since tools can be understood as the bridge connecting humans and reality (Verbeek, 2020).

There are many examples of technological mediation that changes human behavior. Cars, for example, are products which enable us to live further away from work, extending our capabilities and possibilities (Kremer, n.d.). Another relevant example are the CRISPR-babies. In 2018, two twin girls were the first to be born with modified genes. Scientists all over the world had their own opinions on the topic, which led to one important question: how far can Technological Mediation go? (Cohen, 2010)

In the paper '*materializing Morality: Design ethics and Technological Mediation*', Peter Paul Verbeek discusses how engineers are doing "*ethics by other means*", and the possible consequences, such as the raising of moral questions of when a design can influence behavior. Designs can influence people's behavior consciously and unconsciously. If subtle design changes affect how people use it and can incentivize certain behavior, then the designer needs to make sure the scripts are ethical. Verbeek: "*Designers delegate specific responsibilities to artifacts, such as the responsibility to make sure nobody drives too fast, which is delegated to a speed bump."* When technologies are used and able to change human behavior, the script approach is a good way to oversee the intended and unintended mediations: "*it opens up a new way to morally assess technologies with respect to the role they play in their use context."* (Verbeek, 2020). When technologies have a moral dimension to them, it gives designers and

engineers the responsibility to create ethical products.

Verbeek distinguishes two types of mediation: mediation of perception and mediation of action. The first one, mediation of perception, is based on experience and the interpretation of reality. In his paper *Materializing Morality*, Verbeek talks about Don Ihde's Philosophy of technology, which states that technology is not used to be seen on its own, but it enables people to see their environment. It transforms what we see. Furthermore, he states that technologies have intentions. Sometimes, the design provokes behavior it was not designed to provoke, unintended interactions.

The second type of mediation described by Ihde is "mediation of action". Whereas mediation of perception is defined as how people see their world, perception of action conveys the way people live their lives. As Verbeek describes in his paper, Bruno Latour pointed out that people's behavior depends on the materials and designs they have at hand. These materials can either encourage or prevent certain behaviors.

Making a script for an intended design gives a significant opportunity to anticipate both intended and unintended mediations. It allows the designer to take a critical stand and prevent unwanted consequences.

One requirement of the design, and consequently part of our script, is the improvement of healthcare for people in *favelas*. By ameliorating, for example, sanitary services, prevention of the spread of diseases like COVID-19 or diarrhea is also improved. Moreover, the script will describe that the product should be easily manufactured considering the limited amount of resources the people in *favelas* have access to. Furthermore, the design must be understandable by someone without any previous knowledge. This leads to the requirement that the design should be easily fixable, and the different parts should be individually replaceable.

5.2 Capabilities

Capabilities, first described by Sen (1985), are the possibilities and opportunities humans have. In order to attain well-being, one must be in possession of a set of capabilities, which

translate to opportunities to do things they value or become the kind of person they want (Nussbaum, 2000).

Nussbaum (2011) defined 10 basic human capabilities which are according to her necessary to a certain extent for attaining well-being and happiness. It provides a framework in which freedom and opportunities of people can be measured and developed. This set of capabilities is no guarantee of well-being, but they are necessary conditions since people cannot attain well-being without them.

From the Nussbaum-defined capabilities, the most glaring one to be improved is *Life*. The stakeholders are hindered by a lack of access to food, water, and sanitation. A design that betters any of these aspects will inherently improve the stakeholder's lifespan and quality of life. Connected to this capability, there is the *Bodily Health* capability, which has also been left aside by the Brazilian healthcare system. A design that enhances the prevention medicine and local opportunities for healthcare guarantees the improvement of this capability. A design that provides clean water for the stakeholders can significantly improve these capabilities. Also, access to food, water, or sanitation increases the stakeholders' protection against COVID-19 (Oliveira, 2020).

A design that improves the quality of life consequently further decreases the stakeholders' general levels of stress also enhances the *Emotions* capability. The stakeholders will not be inhibited by stress and will be able to process their other emotions more freely (Water, Depression, 2019). If the population is less concerned about clean water and have less uncertainty of water shutting down, they have more time to enjoy life and focus on things that interest them.

One noteworthy aspect to discuss is the possibility of the stakeholders engaging in building the design. If that is a reality, the *Affiliations* capability can be bettered. Unfortunately, the coronavirus pandemic has forced the population to stay at home. Many of the stakeholders are now jobless due to the economic recession. If the stakeholders engage in a project that will ultimately help their own and their loved one's lives, they will feel motivated to collaborate. Interacting with other human beings while working towards a goal for a good deed will significantly improve the stakeholder's level of satisfaction with life, making them feel valued and at the same time useful. The stakeholders receiving

the product also will indulge in a great deal of gratefulness and happiness.

The other two significant capabilities that will be affected by the design are the *Control Over One's Environment* and *Other Species*. Although the ultimate goal of the design is to help the stakeholders, they still have the freedom to choose whether or not they want to implement the design, making them take control and feel more empowered. *Other Species* relates to sustainability, as it is essential to think of the impact a design might have on the environment. Through implementing sustainable materials, the stakeholders will grasp a better connection with nature and will take care of their own environment. This will be discussed in more detail in the following paragraph.

5.3 Sustainability

The integration of sustainability in designing solutions is of great importance. The world is changing and many problems have emerged from the lack of sustainability. Sustainability has a broad definition. It ranges from environmental, economical and social sustainability.

A sustainable design ensures that the concept of sustainability is included through all phases of design ideation. It is important to directly integrate ecological impacts in the design, since 80% of these impacts are locked in at the design phase (Acaroglu, 2020). In order to live in balance with the environment, sustainability has to be integrated in every aspect of daily life. The concept entails that the products used today do not have any negative impact on the current generation and also the future generation (Acarogly, 2020). Furthermore, such a design also entails reducing the negative impacts on health and the comfort of the targeted users (Sustainable Design, 2020).

In order to create a sustainable design, a few objectives should be taken into consideration. Optimizing overall effectiveness, excluding usage of non-renewable energy resources, protecting and conserving water and increasing maintenance practivity are some of those objectives (Sustainable Design, 2020).
Additionally, the design is also ought to be ecological. An ecological design is defined as a design that 'minimizes the environmentally destructive impacts by integrating itself with living processes, nature's own flows, cycles and patterns' (Gultekin, 2009). To make sure that the design is ecological, it is important to look at the seven ecological principles, for

example maintaining diversity and authenticity and broadening participation (Principles, 2020).

Products should minimize their negative impact on the environment. With pressing problems like climate change and biodiversity loss, it is evident that mankind needs to find ways to reduce waste, emissions and use of non-degradable and chemical materials.

Furthermore, the design is part of a closed loop of materials. The earth has a finite amount of resources, which means that technologies should consider the cost and materials of the design process carefully. Economic sustainability can be achieved by improving the life-span of products and making sure that they are repairable. Reusing materials and recycling are desirable in this attitude.

Additionally, the social structure of the favelas is unique, and for the product to be self-sustainable it is important that it is maintained. This is called social sustainability. Minimising interference with this social structure can be incorporated into the design by ensuring the design can be part of the local community and produced locally.

The design includes sustainability and aims to reduce the environmental impact. One example of these measures is the reutilization of dirtied water. The target users can collect the water used for previous hand disinfection and refilter it. The design also includes recycled parts and aims to integrate biodegradable materials wherever possible.
The concept of frugal innovation is essential to consider when elaborating a sustainable design. Frugal innovation is the process of designing low-cost solutions for specific needs and with materials present at hand. The solutions coming from this attitude are most often sustainable, user-friendly and cheap. It takes both the economic, social and environmental aspects into consideration.

When designing for frugal innovation, it is important to note what materials are locally present or easily accessible for our stakeholders. People throw their waste wherever on the streets. Their houses are made of clay, wood and bricks.

Recycling used materials and garbage is one of the ways to make a technology sustainable. In the *favelas*, there is a lot of garbage, like plastic bags and cans, lying around, since there is no unified system of garbage collection. For the design, the way that litter can be reused to be part of our design will be considered as well. This ensures that our design is low-cost, uses local materials and.

Many existing technologies are being repurposed to fit the needs in times of scarcity. For example, scuba diving masks are repurposed with some 3D-printed connection parts to act as medical oxygen masks (Marchese, 2020).

5.4 Appropriate design

Technology can be considered extensions of human capabilities in relation to the world. For example, a bike is an extension with which people can move themselves faster. Another example are scissors, which allows people to cut paper and other materials.

When people generally talk about the functionality of a certain technology, they often mean if the technology works on its own for its intended purpose. A 'good' bike, is based on the intrinsic properties of the bike. Is it sturdy? Do the wheels turn smoothly?

However, technologies are always dependent on how they are being used, their targeted user demographic and its appropriateness in certain environments. Therefore, technologies should not be analyzed on its own, but also its *appropriateness* in relation to its users and context (Oosterlaken 2012). Appropriate design means that the design is suitable for the intended users and context.

Technologies are often designed for the perceived average user. However, this does not immediately take all users into consideration, as some might be excluded. For defining the average user, assumptions of their context and capabilities are made based on research. Although the design might be appropriate for the average user, they do not integrate every single user's profile. For a fraction of the demographic, this design might not be appropriate, does not extend their capabilities and ultimately is considered useless.

For example, a person in a wheelchair cannot use a regular bicycle, which means their capability of transportation is not extended by this technology. Therefore, this design is not appropriate for them. This does not say anything about the quality of the bike for its intended purpose. However, this means products are not always all-inclusive.

Defining who the intended user is and understanding how it might not be all-inclusive is an important part of the design process. Therefore consulting them and letting them have a say in the design process is essential for creating appropriate solutions

2. Urgency

Political figures, philanthropists, and Non-Governmental Organizations have yet to propose a radical solution to revolutionize the way basic needs are distributed among the Brazilian population. After the decentrali-zation of the health system with the implementation of the *Sistema Unico de Saude*, an inevitable strain was placed in small-sized municipalities (SSM's), which compose the majority of Brazilian territory (Pinafo et al., 2020). Considering this situation, far more localized, small-scale solutions were proposed to assuage the issue at hand.

Research Resources

To gather enough information and inspiration for the design, a plethora of resources have been and will be consulted. Firstly, academic research facilitators, such as EBSCO and Scopus, were utilized to ensure that academic-level papers were attained. Academic research papers provide first-hand, peer-reviewed primary information, increasing value and credibility to the information extracted. Moreover, accredited newspapers and news vehicles were used to obtain the most recent news regarding Brazil's situation and the existing initiatives. Even with a substantial amount of research conducted, there are always more tangents to pursue and further information to follow up.

Apart from the research conducted online, the group contacted four stakeholders that work within the health system in Brazil and internationally. The first one, Maria Cristina Barros, is a Military Police captain for the Sao Paulo state and works for them as a doctor. Another woman, Martha Teixeira, works for the Secretary of Health in Bahia as an administrative consultant. Roberto Mathias was also contacted, a medical student in Salvador, Bahia, who interned at Harvard Medical School. The fourth stakeholder contacted was Manoel Galvao Neto, a renowned endo gastrologist who teaches the revolutionary surgical procedures his group created worldwide. These stakeholders were contacted via call, and valuable insights were acquired, such as areas to focus research on and a general overview of Brazil's situation. Furthermore, a critical stance regarding the effects of the COVID-19 pandemic was requested, in order for the pain points to become apparent. Contact with these professionals was key to gather expert opinions and guidance to ensure an useful, realistic design.

Research Highlights

Within the limited time awarded to complete this design challenge, the group intends to research the pain points illuminated by research and discussed during the conversation with the stakeholders. One of these points was to focus on the marginalized minorities, who have difficulties accessing proper healthcare due to the living conditions or prejudice. Minorities such as the Indigenous population have reached the international spotlight due to the devastating effects of COVID-19 to their demographic. Another pain point is the limit access to water inhabitants of favelas have, and the quality of the water that is present.

Existing Technologies

Considering the initiatives aforementioned, it is also important to investigate relevant material technological innovations.

The Federal University in Parana dove into COVID-19 innovation. After a tremendous amount of research, a team constructed a COVID-19 test that costs less than two euros to produce and have the results ready in fifteen minutes. The test demonstrated a 98% efficacy rate (Torres, 2020). This technology is tremendously important for the stakeholders in question, as it is a cheap and effective measure to control the spread of the coronavirus.

One aspect that research recurrently emphasized is the need for clean water. Seen as it is an effective form of preventing COVID-19 infection (Notari & Torrieri, 2020). This issue inherently makes access to clean water a matter of extreme significance to tackle the challenge.

High-Tech initiatives

Even though there are some interesting technologies emerging in the health sector, these are most of the time not accessible or affordable for our stakeholders. Examples are digital services like telehealth, health apps and wearables. These would lighten the load of doctors and medics and would in times of COVID-19 prevent spreading of diseases, however, these are not feasible solutions for the people in the *favelas*. As mentioned in previous sections of this context study, the *favela* population has low income, and limited access to education. High tech innovations tend to require a certain level of background training or experience with technology, inciting a high-level of failure if tried to be implemented in the *favelas*. Furthermore, considering the cost that most high-technology carry, it becomes unrealistic to apply it as a large-scale solution. The obstacles linked to the implementation of a high-tech initiative elucidate the need for a frugal, low cost solution. The solution has to be congruent to the context, being integrative and searching for a greater common good. These issues reinforce the need to investigate the proper requirements, matching with the stakeholder's needs. Even if a technology is efficient and cheap, if it does not incorporate the needs of the target demographic, it is ultimately rendered useless, obsolete.

Water Filtration

Interventions and technologies have been proposed to improve drinking water in the global south. These technologies must be simple, low cost and maintenance, and should require locally available materials. Water, sanitation, and hygiene interventions not only help with the reduction of waterborne diseases such as diarrhea, but also helps decrease the further spread of COVID-19. These interventions have been summarized in figure 2 (Fewtrell et al., 2005) below.

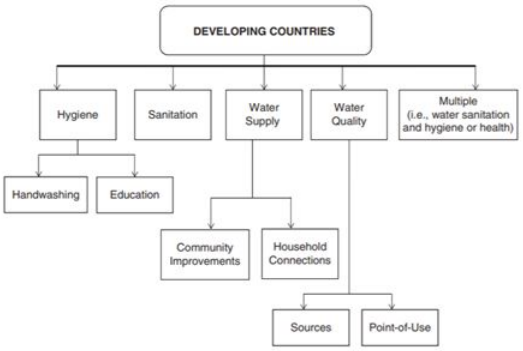


Figure 2, summarization of the interventions

Two important technologies to be inspired by are the biosand filter and the activated charcoal filters. The biosand filter utilizes a layer of bacteria to remove impurities in the water. Using the multiple layer approach, the water comes out well-filtered and potable. The filtration process combines sedimentation, filtration, and disinfection, removing over 90% of pathogens and deactivates and remaining contaminants (Cawst, 2019). The other filter, utilizing active charcoal to purify the water, relies on the adsorption process. Rather than absorbing, the activated charcoal makes the pathogens stick to the carbon molecules, significantly improving the water's quality. The water is stripped from pollutants, while ensuring that the salts and important minerals are maintained (Woodard, 2018). The water is stripped from pollutants, while ensuring that the salts and important minerals are maintained.

As a complement to the filters previously discussed, an invention called "thrifty stand-alone water point" is important to highlight. This innovation describes a water distribution system which also teaches the users how to wash their hands. This concoction can be built using scrap leftover wood and recycled bottles, increasing its sustainability value (Thrifty, 2018). This design makes the user push a lever and maintain their hands under a thin water stream, making them wash their hands for longer periods of time, reinforcing a very important aspect of washing hands properly. (Thrifty, 2018)

Figure 1, Thrifty stand-alone water point

These solutions are inspiring in the sense that it is possible to make a change with available or easily accessed resources. Both these solutions are considered to be frugal, as they are cheap and get the job done effectively.

Another important invention is the use of Point-of-Use devices, since these allow individuals in developing countries to improve the quality of their drinking water. It is important to develop an efficient and sustainable technology, since community water treatment plants are mostly inexistent in the favelas. (Fewtrell et al., 2005)

The use of POU devices has been recommended, since it has been proven that water treating at home is more effective than improving the quality of the source. Nowadays, the POU methods at home are based on 'boiling, filtration, solar disinfection, chlorination or flocculation in combination with chlorination' (Water Treatment, 2020)

Additionally, it is also important that further measures are taken when it comes to the recontamination of the treated water at home. One measure that can be taken to avoid this is to use narrow-necked jars instead of wide-necked ones which allow recontamination, which can be seen in figure 3.

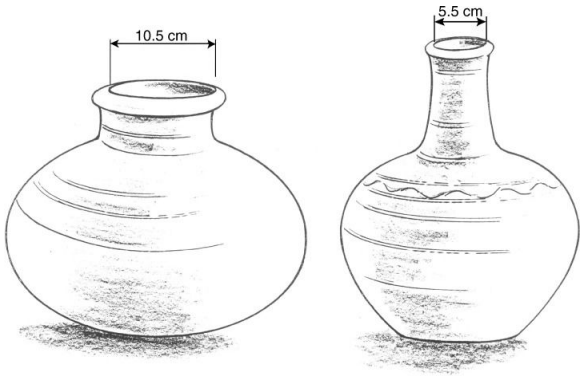


Figure 3, wide-necked and narrow-necked jar

Another important existing initiative is Heat-based technologies, this includes the boiling and pasteurization of water. Boiling is one of the most effective and easy methods, it has the advantage of killing most pathogens and parasites. Boiling water is practiced in 21% of the households that were surveyed

(Rosa and Clasen, 2010). Almost 98.5% of the boiled water samples that were researched showed a 98.5% inactivation of Escherichia Coli (Brown and Sobsey, 2012). The incomplete samples may have been caused by incomplete boiling or pasteurization. Furthermore three-fourths of the samples met the WHO guideline, which inherently means that the water is drinkable.

This practice also has disadvantages, for instance, the inability to "reduce turbidity, fuel cost and the lack of protection from post contamination'" (Psutka et al., 2011). Furthermore, the burning of biomass such as wood, may decrease the quality of the air, as well as contribute to greenhouse effect. The daily supply of drinking water per day is approximately 10 L, boiling this requires three times the fuel needed to cook the daily meals (Gadgil, 2008). Boiling this water indoors leads to an estimated 1.6 million excess deaths from smoke inhalation (WHO, 2008)

Furthermore, there is the Biosand filter (figure 4). It is a household device that was developed by David Manz of the University of Calgary, Canada.

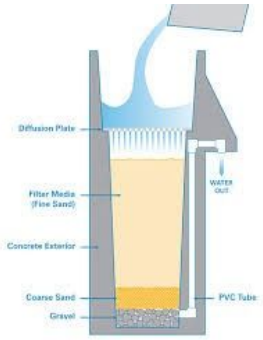


Figure 4, Biosand filter

The device is based on slow sand filtration, which takes 18-22 hours. The device was developed for people with no access to safe clean water in developing countries. The outside of the device is made out of plastic, which is lightweight and easily transported. Biosand has many advantages, such as, 'low cost, ease of use and maintenance, sturdy design, relatively high flow rates, and ability to treat turbid waters' (Tiwari et al., 2009). Between 1999 and 2010 a study was conducted in Haiti, which showed an average of 92% removal of E. coli. The use of Biosand led to a significant reduction when it comes to diarrhea (Stauber et al., 2009). Factors that influence the efficacy of the filter are sand size and bacterial layer degradation. Over 99% of cyst-like pollutants were removed from the water. (Palmateer et al., 1999).

A fifth existing initiative is Ceramic water filters. These POU devices include 'cloth and

fiber filters, membrane filters and ceramic water filters'. Ceramic filters remove from 97.8% to 100% of E.coli (Oyanedel-Craver and Smith, 2008), furthermore, it also removes 75.1% of thermotolerant coliforms (Clasen et al., 2005). The overall percentage within the WHO risk categories is shown in figure 6. (Clasen et al., 2005).

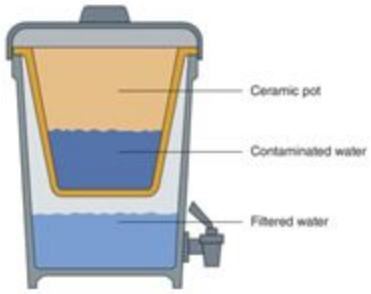


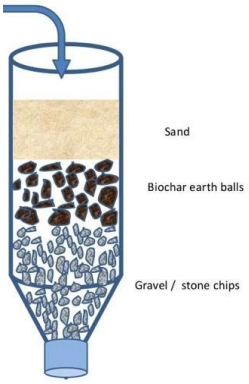
Figure 5, ceramic filter

	Percentage of Samples by WHO Risk Category			
	0 TTC/100 mL	1-10 TTC/100 mL	11-100 TTC/100 mL	101-1000 TTC/100 mL
Control group	0.86%	7.30%	37.34%	54.51%
Intervention group	47.66%	24.22%	17.58%	10.55%

Figure 6, WHO risk categorization

These technologies will act as an inspiration in the next phase, where the design will be ideated.

Another existing technology is a filter made from different natural materials: activated charcoal, sand and rocks. Each layer of the filter suits a specific purpose. The gravel, or small stones, on the top layer, filters large contaminants, like leaves or insects. The two types of sand are used to remove impurities. The activated charcoal is extremely important, as it removes contaminants through chemical absorption. It provides an adherent surface that sticks and deactivates the contaminants. The last aspect is a cloth, to ensure that nothing gets through to the outputted water (Clansen et al, 2005).



Slow-filtered water has shown impressive results. Assumptions about using sand to filter water have been made, many of those being that this way is old-fashioned and ineffective because of the gravitational pull. These assumptions have been shot down by research that illustrates, under the proper scenario, slow sand filtration is one of the most efficient ways of treating water. This method is frugal, as a cheap, yet effective method, being more effective than faster ways of filtering water for disinfection (Sawant, 2018). Furthermore, this method is superior because it uses local, accessible materials and can be easily taught in any community.

The major problem encountered when implementing this filter as a large-scale solution is obtaining the activated charcoal. Considering it is the ingredient that ultimately

purifies the water from bacteria's, access to activated charcoal has to be ensured.

On a rudimentary level, charcoal can be made through a relatively easy process. Utilizing burnt wood or organic material, the charcoal can be activated by adding pulp-free lemon juice. The burnt material can be mixed with the lemon juice to a paste-like substance, and covered for 24 hours. After that, the charcoal present in the material is activated. The slow-filtering process combined with the active charcoal has shown impressive results in research and field testing. It has shown 99.9 protozoan reduction, 90-99% bacterial and variable viral reduction. The tests further demonstrate a removal rate for the Escherichia coli bacteria of 90-98%, resulting in a 47% reduction in diarrhea cases for those who use the filter (Sawant and Abhishek, 2018).

The filter can continue working for weeks, maybe months, without being cleaned. The more robust impurities can be easily removed from the top layer. With continuous cleaning and care, the filter can be used for up to five years.

The final existing initiative is soap. There are different ways to make soap, some more difficult then others. The following is a family recipe. This soap works by breaking apart the protective layer germs have on the outside, making them vulnerable and rendering them incapable. The soap also traps and removes the contaminants and oils present in the surface being cleaned, that is why it is crucial to wash hands with the soap for at least twenty seconds. The longer the washing process, the more effective the soap becomes in flushing the bacteria (Dalahmeh and Bell, 2020).

The coronavirus has a lipid protective layer, it will be deactivated by this soap. It is not applicable to every virus as some have outer layers made from protein, consequently becoming resistant to soap (Coronavirus, 2020).

The only ingredients needed for this soap are 5 kg of leftovers frying oil, 5 kg of water and 1 kg soda (NaOH) dissolved in 2 kg of water.

Conclusion

This context study provides an overview of the challenge being tackled. The study sheds light on the current situation and needs of the stakeholders, on the context the design will be used in and on considerations of responsible design, tackled in the lemniscate. The stakeholders were researched in depth and will be involved in the design process, in order to create appropriate and inclusive design. The context of the design was discussed, also how the concepts of mediation and capabilities can be incorporated to create an ethical design. A focus on sustainability and its impact on product design were explored together with the responsibility designers have. Some emerging technologies were presented and evaluated. All these factors around the lemniscate sum up the main inputs we will be taking into consideration while making the design. The lemniscate provides a synopsis, a clear connection between the design, stakeholders, and the context pertinent to the solution.

Conclusively, this report successfully covers many relevant aspects concerning the challenge being addressed and deliberated upon its possible implications. Therefore, it acts as a basis from which we can start designing the solution.

The next step, described in the analysis of the script of the design, is to define functions and requirements based on the values and capabilities described above. Furthermore, the intended interactions between the stakeholders and the design will be ideated, which is an integral part of the lemniscate.

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