Master Thesis

Stimulating repairs on small household appliances among Dutch citizens

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Abbreviations

SHA - Small Household Appliances
SPT - Social Practice Theory
RC - Repair Cafe
BIT - Behavioural Insights Team
EEA Coalition - Electrical and Electronic Appliance Coalition
BKN - Brancheverenigingen Kringloop Nederland

Abstract

Small household appliances (SHA) are a major part of e-waste, yet many repairable devices still get discarded. This study looks at why consumers—especially 18-34-year-olds with higher education—aren't repairing their stuff. Using Social Practice Theory (SPT), it breaks repair down into three parts: images (social norms and emotions), stuff (tools, product design, and spare parts), and skills (repair know-how).

Research shows that while many people are willing to repair, they see it as too hard, time-consuming, or simply not worth it. They lack the right tools, struggle with fault diagnosis, and don't know where to start. Manufacturers set consumers at a disadvantage, making repairs harder with proprietary parts and poor access to manuals.

To address these issues, a design intervention was developed that seeks to lower psychological and practical barriers to repair. This intervention includes a service model that provides structured fault diagnosis strategies, essential tools, and guidance to consumers. The goal is to make repair more accessible, engaging, and socially accepted within the target demographic. The proposed solution was evaluated based on feasibility, user acceptance, and potential impact on repair behavior. Results suggest that interventions combining practical support with social reinforcement can significantly increase repair engagement.

This research contributes to the broader discussion on sustainable consumer behavior and circular economy principles by demonstrating how design strategies can influence repair propensity. Future studies could further explore policy implications, industry cooperation, and scalable interventions to enhance consumer participation in repair practices.

Table of Contents

01 Introduction

This thesis, which is done for the master Design for Interaction, focuses on the stimulation of repairs of electronic devices done by citizens in or around their home environment. This thesis is done in collaboration with the Behavioral Insights Team of the Ministerie and with the EEA coalition. In this report a design intervention will be introduced for that specific focus. In this chapter specifically, the set-up of this thesis will be discussed. In Chapter 1.1 the structure will be laid out, in Chapter 1.2 some boundaries will be set for this project and after that the updated project goal will be stated.

1.1 Report structure

This report has two main pillars it will build on, namely the Double Diamond model (Design Council, 2005) and Social Practice Theory (Shove et al, 2012). The former is in design research widely used, and describes the design process in a global way. The latter will be discussed below here. After having explained this, the structure of this report will be laid out.
Practice theory is a framework to understand society (Kuijer, 2014). To form it in my own words: it is a way of researching where you observe a practice as close to reality as you can, to see how the people doing this practice give this shape through their own thoughts and in their own environment with the resources they have at hand.

A practice consists of three components (Shove et al, 2012). Stuff refers to objects, infrastructures, tools, hardware and the body itself. Secondly, the skills. Skills are learned routines, both mentally and bodily, they are formed during someone's life and are about how competent someone must be to start or complete a certain practice. Thirdly, the images come into play. These are concepts or socially shared ideas of the world around this practice (this can be different for where this practice is done and by who it is done).

This is about values and norms, and ideologies around this practice. In the context of repair, "stuff" refers to the product itself, such as a washing machine, toaster, or laptop, but it extends far beyond these items. It also includes the supporting logistics systems.

For instance, is there a repair professional or retailer nearby where you can drop off a broken vacuum cleaner? Do you have access to the tools needed for repair, like screwdrivers or a soldering iron? If not, how easy is it to obtain these tools?
The "skills" element encompasses the expertise and competencies required to repair a specific product. This includes the ability to use necessary tools, the technical know-how, and the process knowledge to determine how and when to take certain steps—for example, knowing how to solder and identifying when this is required. It also involves understanding what to prioritize and what potential issues to watch for in specific appliances.
The third element, "images," relates to the societal meaning of a practice. For example, you might choose to repair appliances not only for practical reasons but also because your peers value sustainability and emphasize the importance of preserving the planet. These shared norms and values influence the symbolic significance of the practice.

Now, the foundation for this report is clear, which makes discussing the structure a lot easier. Chapter 1, as discussed in the beginning of this chapter, is about scoping and introducing. How is the report built up, what is interesting and how can the product be scoped in such a way that the outcome will be better. Then the discovery phase starts, hereby introducing the factors involved in the Social practice Theory model (SPT).
These include Image (Chapter 2), which discusses the social norms and the time factor in repairing. Chapter 3 discusses the Stuff and lays out the design of appliances and the essentials necessary for repairing them. Chapter 4 dives into the Skills needed for repair. Chapter 5 introduces the stakeholders that have an influence on repair and Chapter 6 discusses the research I did with the target group discussed in Chapter 1.2.2.

After that, the most important takeaways of these chapters (2-6) will be taken into account to form the design goal and requirements (Chapter 7), which makes up the Define part of the Double Diamond model. After that we switch over to the Develop part where ideas will be turned into one final concept. This concept will be elaborated on in Chapter 9 and validated in Chapter 10. In Chapter 11, I will give an overall reflection based on this report.

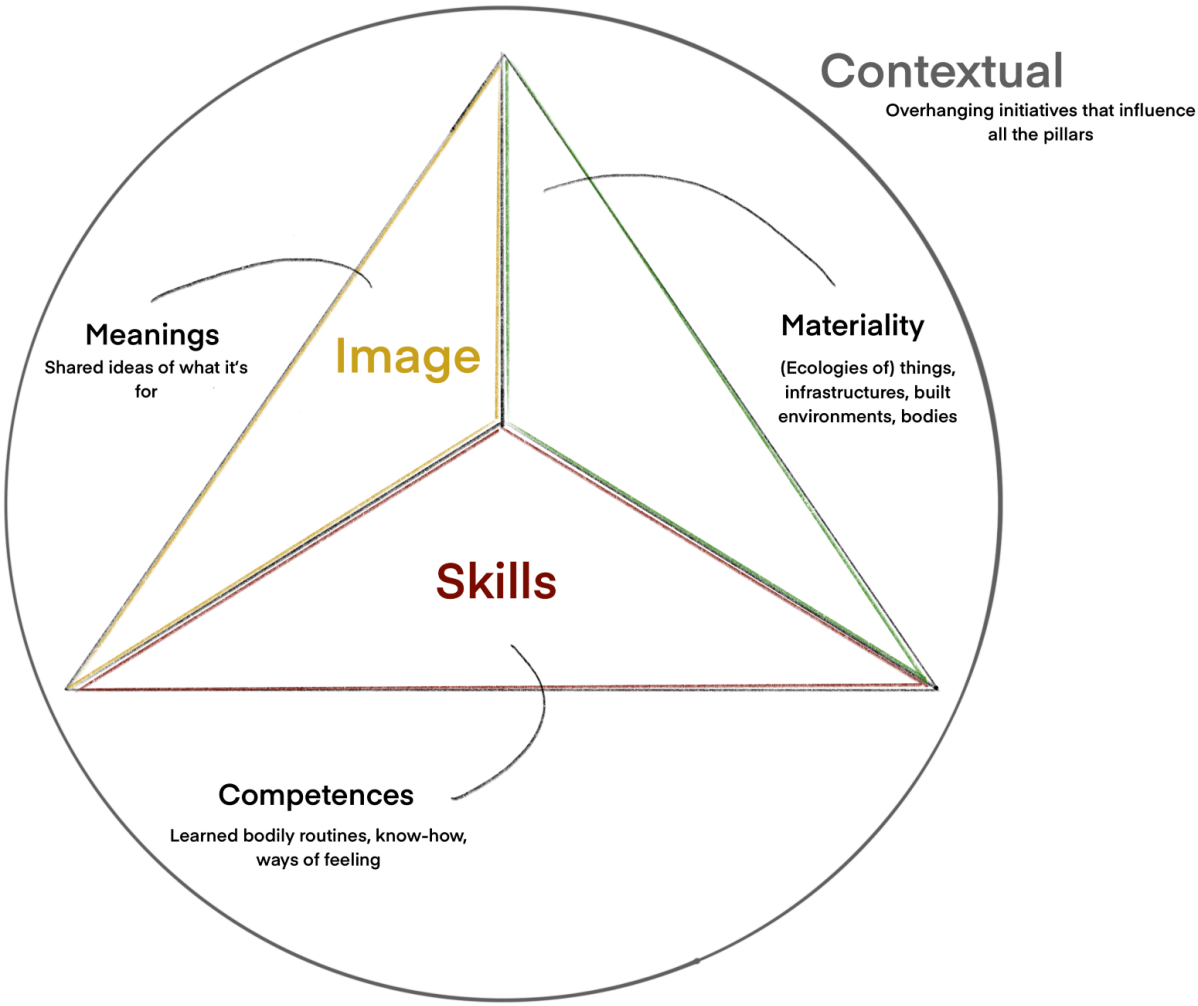


Figure 01: Three components of SPT + contextual factors

1.2 Scope

In this part of the introduction, the project will be scoped. Boundaries of the project must be set to ensure a well functioning design intervention. The following aspects will be discussed: the target group that is most open to perform the practice of repair, which product category is the most promising and lastly, which components of that product category are the most prone to failure.

1.2.1 Product category

As stated in 4.1, a lot of electronic products are being discarded. According to the Global E-waste Monitor (2024), e-waste can be divided into six categories: temperature exchange equipment, screens and monitors, lamps, large equipment, small equipment and small IT and telecommunication equipment. Which appliances fall under these categories is stated in Figure 02.

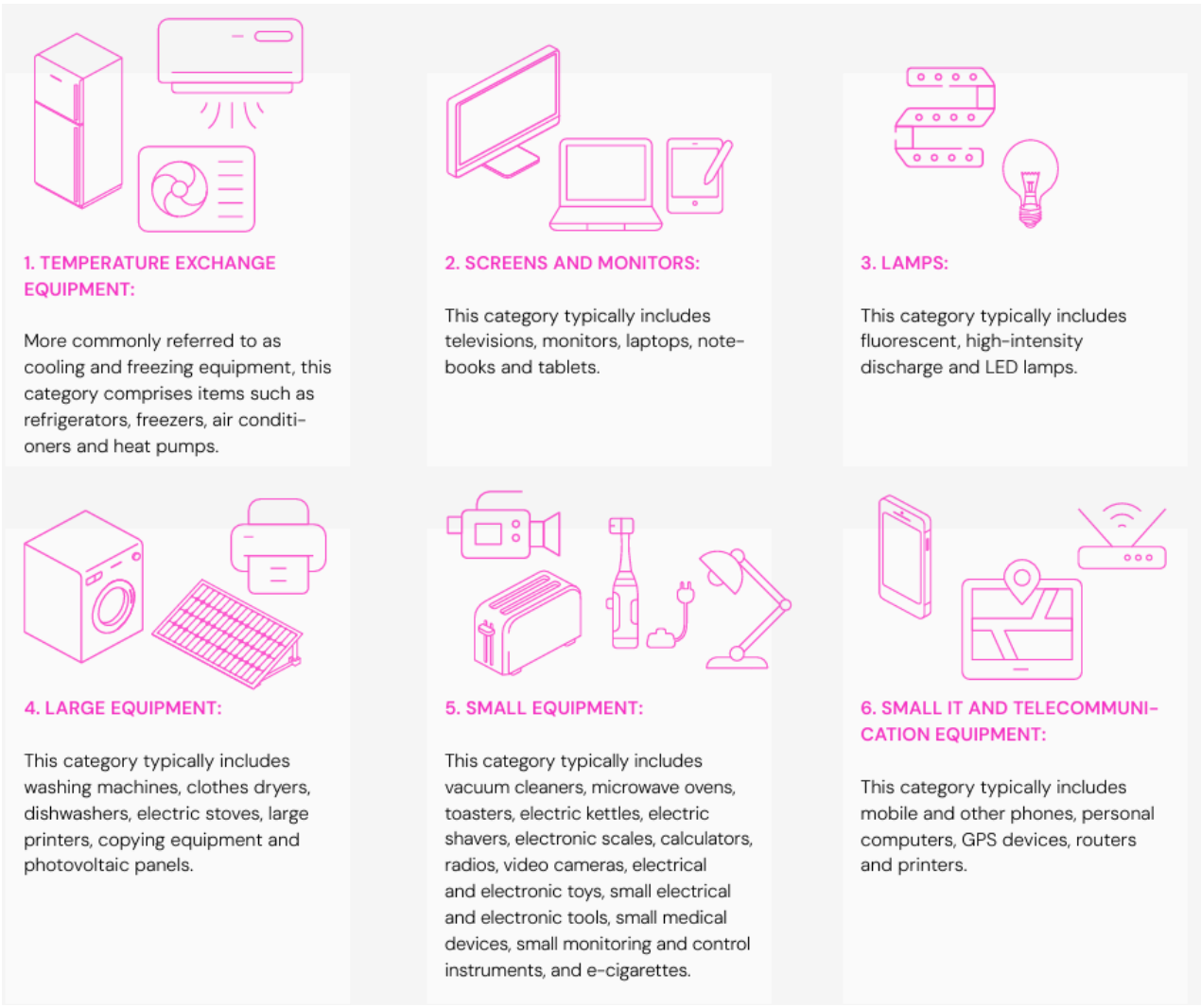


Figure 02: Discarded electronic devices categories

When ranking these six categories by the amount of e-waste they produce, small equipment emerges as the clear leader, generating 20.4 billion kilograms, followed closely by large equipment at 15.7 billion kilograms. Next in line are temperature change devices, followed by TVs and monitors, small IT equipment, lamps, and photovoltaic panels.

Within the small equipment category, only 12% is formally collected (The Global E-waste Monitor, 2024). This low collection rate is primarily due to these items being stored for years in people's cupboards or discarded in regular household trash, a practice adopted by over 90% of households (Bovea et al., 2017).

When this waste is improperly disposed of, similar to other household refuse, it can release significant amounts of heavy metals, including lead and mercury, into the environment, which can negatively impact air, water, and soil quality (Gaidajis et al., 2010).

There is substantial potential in small equipment (Figure 03) (The Global E-waste Monitor, 2024). To clarify, small equipment refers to household items, particularly vacuum cleaners, kettles, toasters, and other small kitchen or household appliances. Research on these items is more extensive compared to the latter portion of the small equipment category (Figure 02).

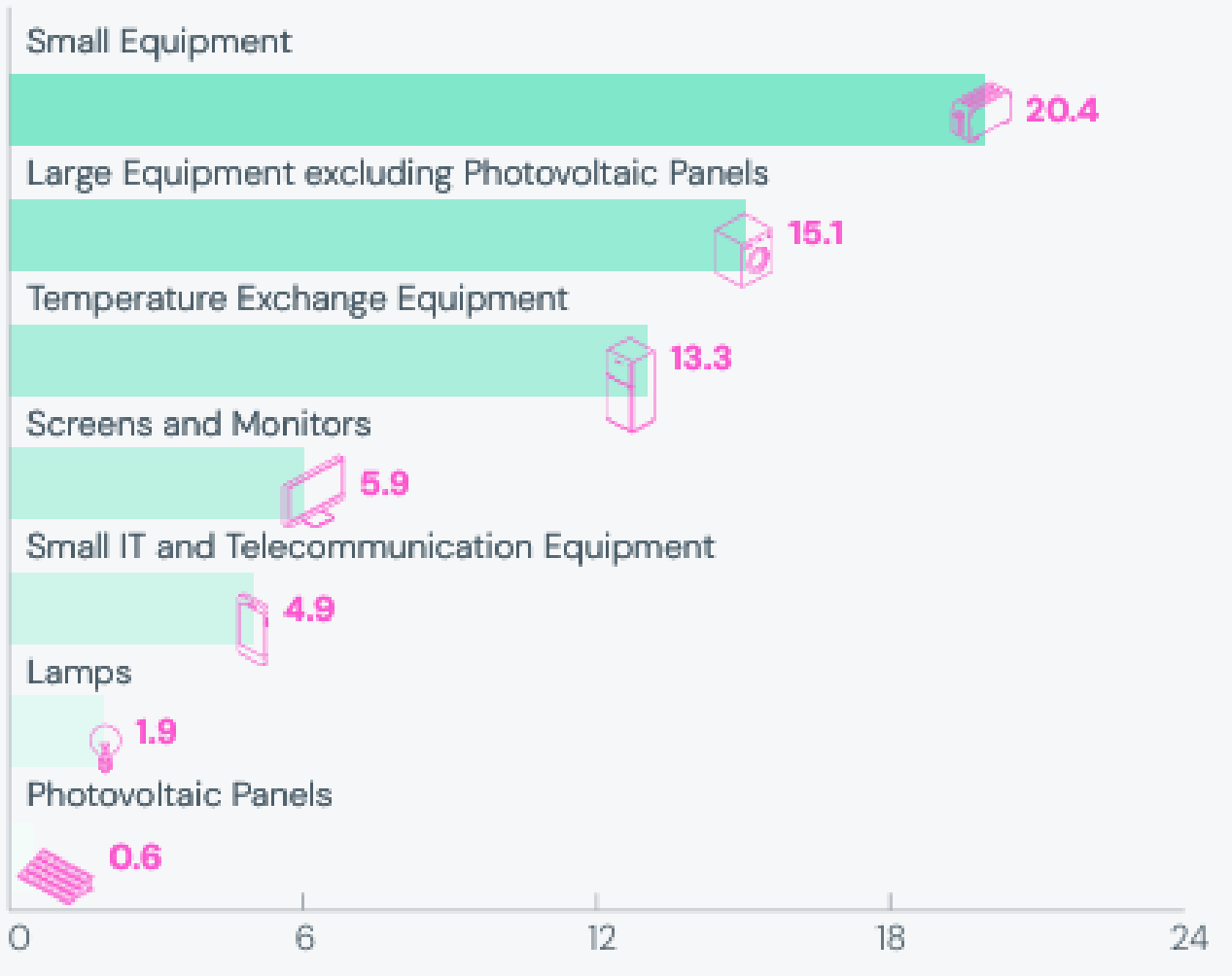


Figure 03: Total E-waste generated by category of devices in billion kilograms (global E-waste Monitor, 2024)

Not only is there a significant amount of waste generated annually, but consumers also report greater self-assessed repair skills and a stronger desire to enhance these skills specifically for small household appliances (Lundberg et al., 2024). Additionally, Bovea et al. (2016) found that among a sample of 96 discarded small household appliances, 69.8% were still repairable, while only 2.1% needed cleaning. This indicates that a considerable portion of disposed products can still be fixed.

For these reasons, I will focus on small household appliances in the upcoming chapters.

According to Figure 04, the most common issues with these appliances include damaged electronics (38%), cable breakage (34%), and mechanical problems (21%). The mechanical problems consist of dirt (14%), damaged casing (2%), and damaged buttons (5%) (Bovea et al., 2017). Since resolving the dirt issue typically requires opening the appliance to clear any debris that may hinder mechanical functions, it can be categorized under mechanical issues (Bovea et al., 2017). While these challenges may be daunting for novice DIY repairers, given that electronics fail 38% of the time, they must be addressed in my proposed solution. Furthermore,

attempting to replace main components (7%) in small household appliances is often not financially viable, as the costs—around 40-50 euros—are too high compared to purchasing a new product. This makes buying a replacement more beneficial.

The faults that happen the most are electronics faults, followed by breakage of cables and mechanical problems in small household appliances.

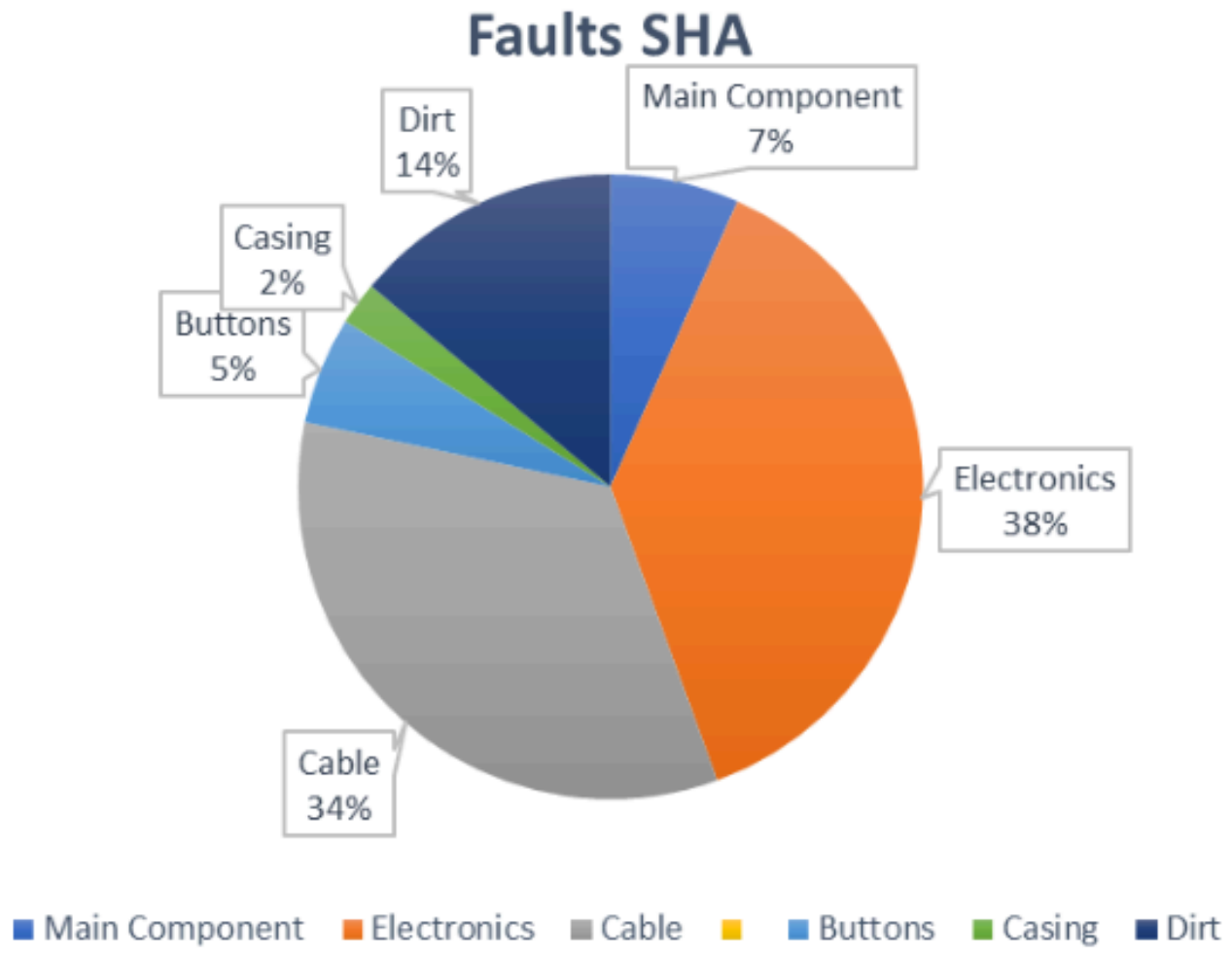


Figure 04: Sorts of faults and their commonness in them happening

There will not be huge difficulties with replacing a cable, since knowing what defect it is, is easy to assess, and there are no difficulties accessing it. For damaged electronics, one might need to go into the core of the problem, so the consumer has to be aware that all of the mentioned problems in Figure 05 can occur, such as hidden screws (11%), different screw heads (8%), the inability to access certain parts (5%) and busted buttons (5%). But in most cases (67%) no obstacles are found, this is because in most of the cases the repairs are cable repairs because and since repairing a cable does not have a complex disassembly sequence no obstacles will be found (Bovea et al, 2017).

These same problems might occur for mechanical issues, although these problems are more on the surface than electronics faults (Bovea et al., 2017). For the electronics and mechanical problems, the consumer might need to find a spare part (8%), which can be quite difficult, especially for vacuum cleaners. This is something that cannot be designed for, since the availability of spare parts is different per brand and per product. If a part cannot be accessed, this part should be replaced as a whole. This is also something that cannot be designed for, since

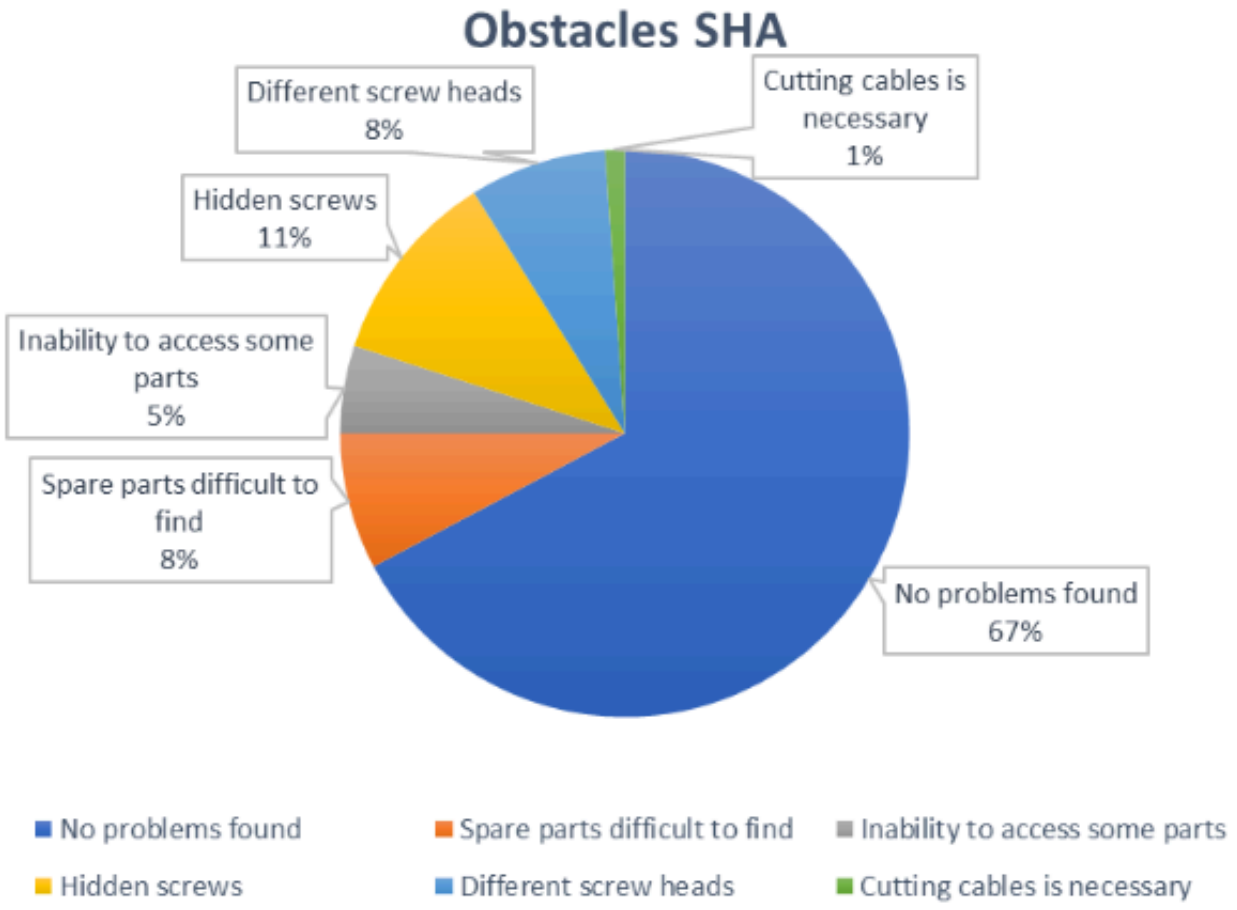


Figure 05: Main obstacles of getting to the assessed fault

that has to do with the design of everyday products. **The obstacles in assessing the faults can be solved by either having the right set of screwdrivers, short and long, with different screw heads or by taking more time to find the screws**

1.2.2 Target group and lifestyle

It is important to find out what my target group is. How do they look at sustainable behaviour, is repair or getting products repaired normal among this target group or frowned upon? These are questions I will try and answer in this chapter. I will first look at what my target group is and then I will go into what their mindset is, their norms and values and what sparks their interest. In general, there is a lot of potential for (diy) repairs. In a survey of Geeris et al. (2024) it states that only a third of all Dutch households repair their domestic appliances, although 75% of all households say that they are willing to do so. There is a big gap between intention and target behaviour which means that there is a big difference between what people want to do and what people actually do. It can be concluded that this gap shows that there is a potential for the repairs of household appliances. According to Geeris et al (2023), the consumers with a high education and income are less sustainable overall. They fly more, buy more clothes, take the car for short rides and they live in bigger houses relative to the rest of the Netherlands (Geeris et al., 2023). Interestingly, it is also this group that has the highest openness for repair: 80 out of 100 relative to people with a lower income and education who have 25 out of 100 (Geeris et al., 2024).This highly educated group also wants to develop their repair skills more compared to people with basic education. However, according to Lundberg et al. (2024), a lower income will also increase repair propensity. **Thus, people with all incomes and higher education will be selected for this thesis.**

For people with a younger age (18-34) we see the same sort of pattern that we saw in income and education. They are more open to live sustainably, but do not always do this yet. They fly more and they buy more clothes than older generations (Geeris et al., 2023).
According to Fachbach et al (2022), older people tend to repair things more often than younger people, which means that the target behaviour for older consumers is already there. This is not the case with the younger generation. They are also willing to develop their repair skills further (Lundberg et al., 2024). **This is why we choose the target group of people from 18-34.**

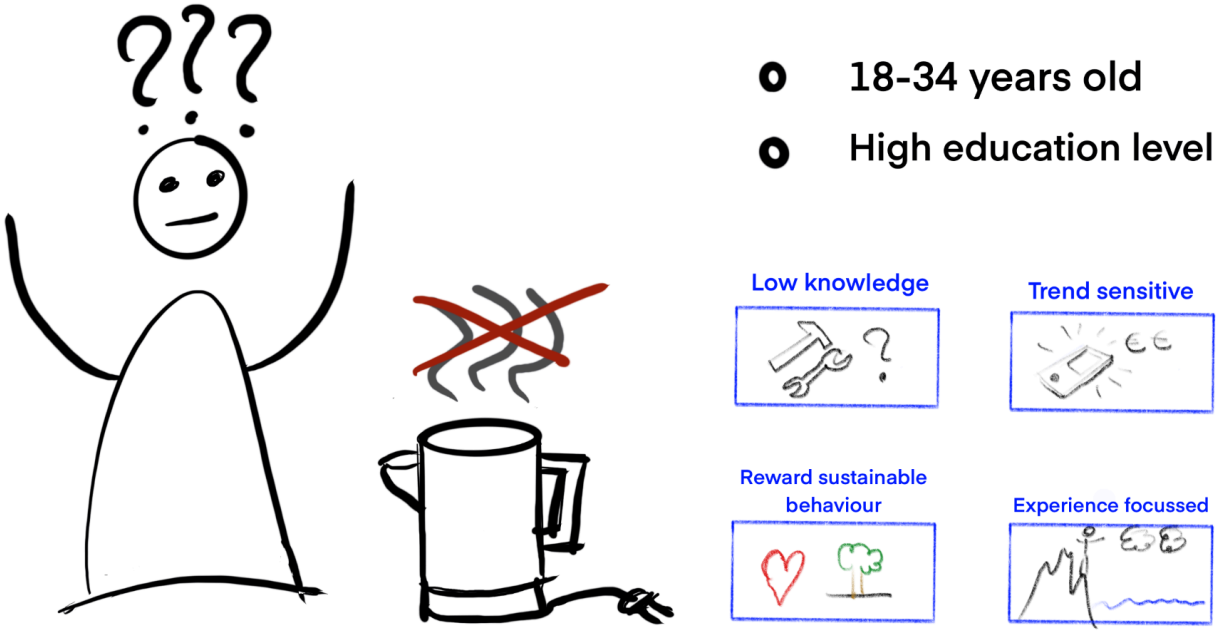


Figure 06: Demographic characteristics of the target group

Takeaways Chapter 1.2

- The design will be for consumers between 18-34, with a high education. They are more open to sustainable behaviour but they do not act on it yet.
- This target group can be targeted by:
  - Being transparent
  - Rewarding sustainable behaviour
  - Creating something that is modern, personal and can benefit social status
  - Making the threshold low to use
  - Focusing on self-development and experience in life
- The products that will be targeted are Small Household Appliances
- The faults that happen the most are electronics faults, followed by breakage of cables and mechanical problems in small household appliances.
- The obstacles in assessing the faults can be solved by either having the right set of screwdrivers, short and long, with different screw heads or by taking more time to find the screws.

1.3 Project Goal

The goal of this graduation project is to create an intervention that could stimulate people to repair their own small household appliances.

A. Discover

This part is about the first phase of the double diamond: the discover phase. As this thesis is about stimulating repairs of electronic products for consumers in or around their home environment, this phase will be about analysing the broader context of electronic products that have an effect on this behaviour.
If we look at practice theory, there are the three pillars that this practice revolves around, namely Images, Stuff and Skills.

Chapter 2 will go into depth about the Image of repair, Chapter 3 about the Stuff (the built environment and the resources), Chapter 4 about the Skills (the competency of the practice), Chapter 5 about which contextual factors play a role in this, such as manufacturers, governmental policies and repair initiatives. Chapter 6 is about the research that I conducted myself about the obstacles that the specified target group has during repair.

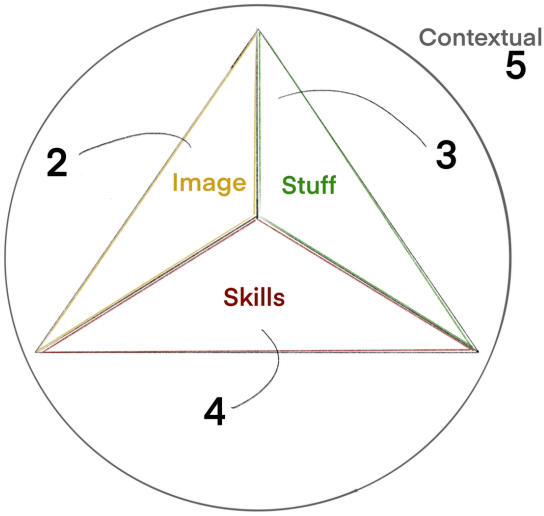


Figure 07: How the elements of SPT are divided in this thesis.

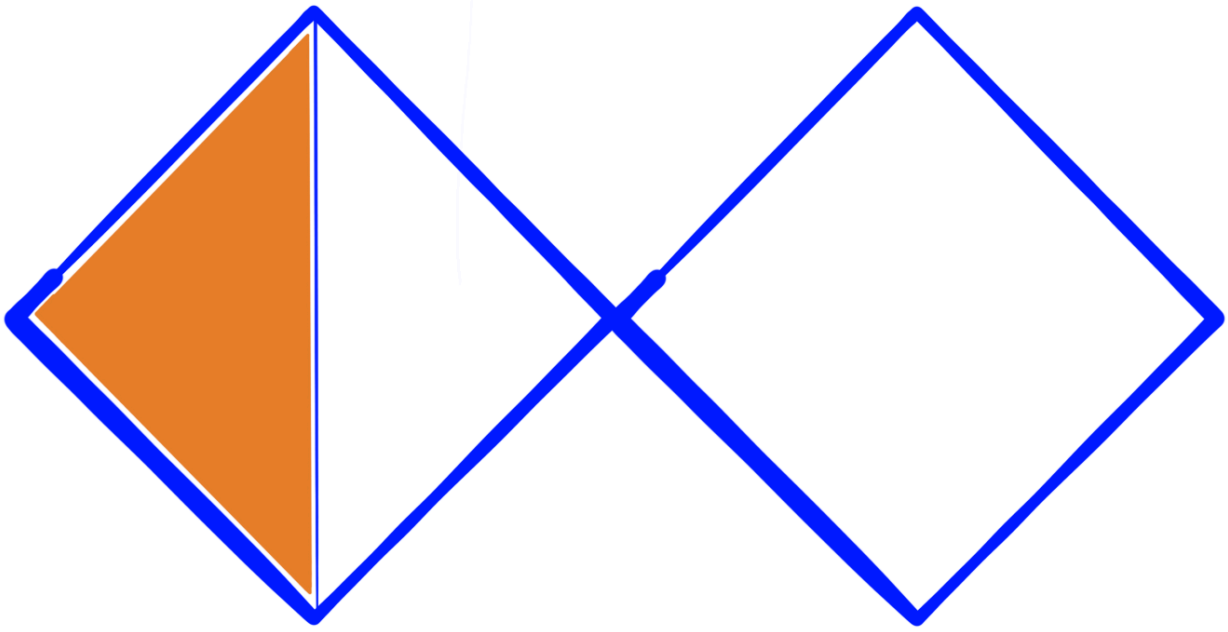


FIgure 08: Discover, the first part of the double diamond model

02 Image

In Chapter 1.1, we explored that SPT is built upon three pillars along with a contextual factor. This chapter will focus on the role of imagery, specifically the emotions that influence consumer decisions regarding repair versus replacement. We will also examine the product itself, investigating which emotions or sentimental attachments motivate consumers to retain items, and how this impacts their sense of agency and confidence. The guiding questions for this chapter are presented in Figure 09.

2.1 Replacing vs repair

The first subject is what makes people choose repairs over replacement and the other way around. Which factors are important and why?

2.1.1 Time

Time is a very important factor. There are three types of time in terms of the repair of small household appliances. Two of them are active and one passive. The active ones are firstly: time spent researching everything from looking up which spare part you need for that certain product to looking for information on how to repair a certain product and secondly the time you spent on the actual repair. All active styles of time are linked to effort, because what takes up time, takes up effort. This is a positive correlation. The passive time is waiting for certain parts to arrive, since the person repairing the device does not have to do anything but wait (Svensson-Hoglund et al., 2022c). If the effort of repairing is the same as replacing or higher, in most of the cases users will opt for a replacement. **The longer it takes to repair a product, both passive or active, the less likely a user is to continue or begin the repair.**

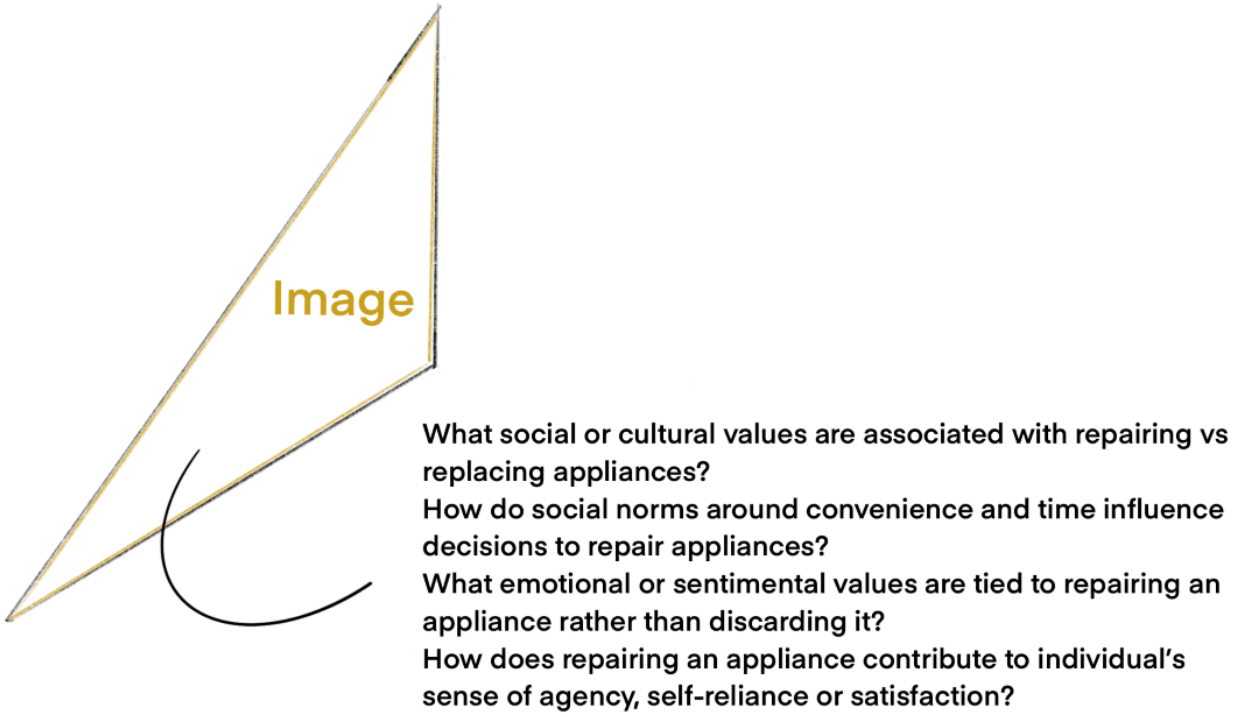


Figure 09: Image, the first part of the Practice Theory model

Furthermore, If the effort of repairing is the same as replacing or higher, in most of the cases users will opt for a replacement.

Lastly, the duration for repairs varies. It depends on a lot of things, what component is broken, where it is in the product, if a spare part needs to be ordered and so on. This will be discussed more elaborately in Chapter 3.1. This makes it variable from five minutes to however long it takes. When time is spoken of with replacing, especially with small household appliances, it can be one click of a button, and in some cases the product you want can also be found in the local supermarket, or electronics store. With providers like Amazon, CoolBlue or Bol, a product is sent to you the next day. If something breaks before 22:00 o clock, you have a replacement the next day. This time is set in most cases. You know that the company from whom you buy it, can have it the next day. It can happen that in some cases it takes longer, but normally this would never be a problem.

The time a repair takes should be given from the start, although this is an estimation, since a repair always brings forth unexpected problems or difficulties. An idea can be given to the user so that they know what they can expect, since this is what makes replacing a very suitable option. A buffer always needs to be added in the expectation, so that if something might go wrong, there is still room to complete it within the estimation that was given at the start. **Expectation management and convenience of use is key in a potential design intervention.**

The second factor has more to do with a consumers' inner circle and past influences, since a lot of the social norms around repair are dictated by what that person is exposed to in his/her youth. Is it normal for that person's family to repair, is it normal to do in

2.1.2 Social norms and emotions

their neighbourhood or community, in school and were there Repair Cafes around where that person lived. This makes repair a more ingrained activity in their life and thus creates a habit (Svensson-Hoglund et al., 2022c).
Not only their upbringing can create a difference in repair propensity, also what people or peers that person surrounds themselves with. f these friends are also willing to repair their broken devices, together with local Repair Cafes or DIY shops, this can build someone's repair capital, which ranges from accessibility to tools and spaces, enhanced with access to information and knowledge (Svensson-Hoglund et al., 2022c). Are these friends helpful to them, or do they also follow the latest trends, i.e. throwing away the old model to get the newest latest model?

The social context can steer more to novelty than repair, since having the latest model is parallel to being successful, which leads to a better perceived self-image and social identity (Svensson-Hoglund et al., 2022c). This social circle can also influence the knowledge in such a sense that there might not be any awareness of repair. The rule is replacement, and repair is not even an option, or that a product is irreparable, a problem in this might be that there is not enough awareness in the media or by peers that address this as an issue (Roskladka et al., 2023b). According to Roskladka et al. (2023) unawareness is the most important issue for consumers to not repair (Figure 10) and Mugge & Magnier (2022) state that 60% does not even consider repairing their device. To change this behaviour, a consumer needs a trigger together with the ability to do a certain repair, alongside with the motivation to do so (Arcos et al., 2021). **A trigger, targeted on the unawareness issue, is necessary for an impactful design intervention.**

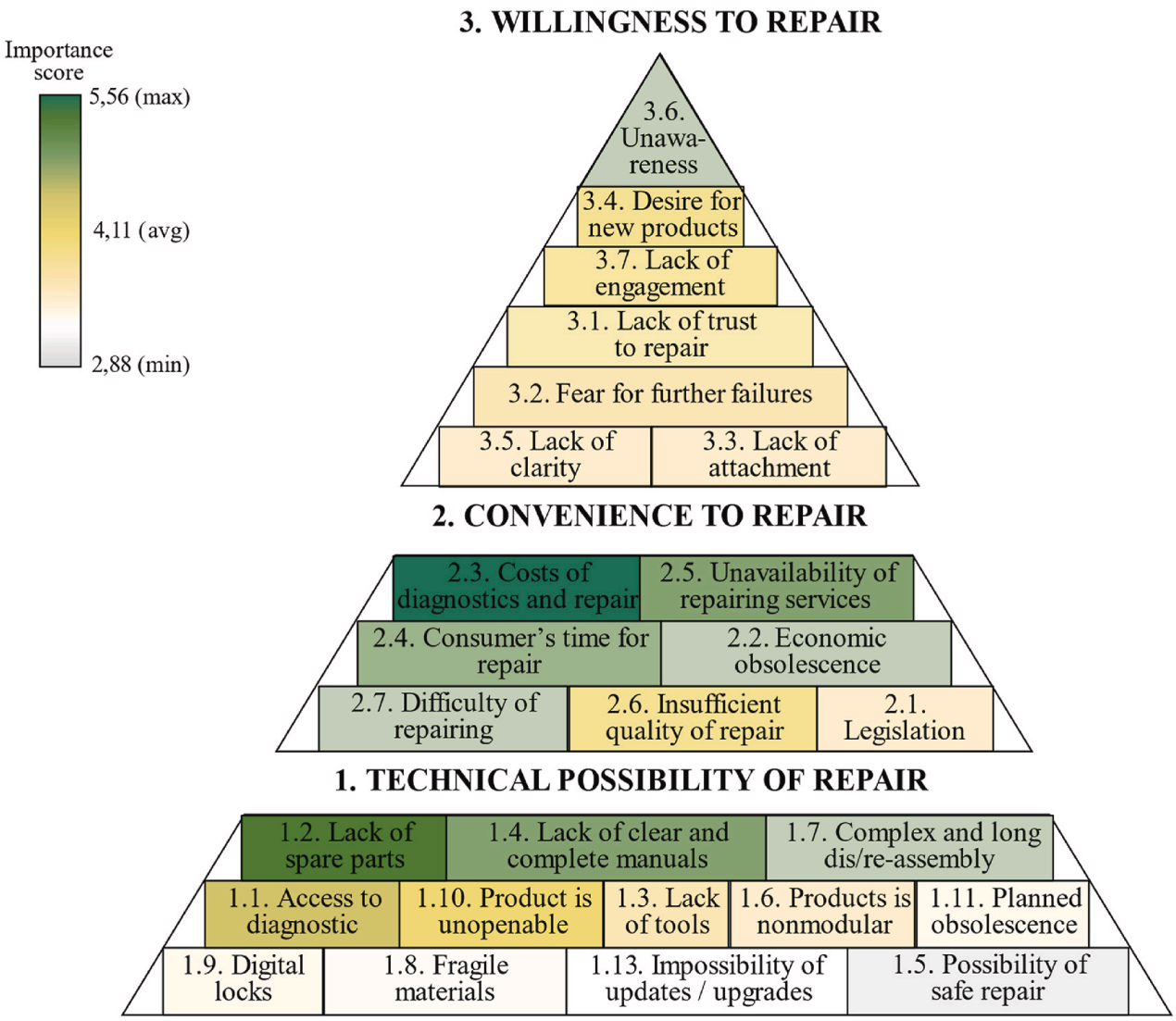


Figure 10: The importance score of diffferent barriers for repair (Roskladka et al, 2023b)

There are a lot of questions that arise when a consumer is thinking about either repairing a certain product or throwing it away. The reasons for discarding will now be discussed. One of these is the appearance of a product. If a product has visual damages it can create negative emotions towards a product and trigger possible replacement. Sometimes it can trigger this behaviour if a product is used for so long that the consumer mentally has depreciated it, which leads to decreased enjoyment and less desire to prolong the use of this product (Magnier & Mugge, 2022b).

Furthermore, a lack of emotional attachment can also make users shorten the lifespan of a product.. Discarding can also happen due to external factors that have nothing to do with that certain product, this happens when new products come onto the market with more tech-savvy features or when new fashion trends arise (Roskladka et al., 2023b). Moreover, people can also be triggered by the thrill of acquiring something new (Magnier & Mugge, 2022b). When consumers opt for repair, it is often a time-consuming and inconvenient process, this often leads to frustration (Scott & Weaver, 2014). Lastly, they do not understand what good quality of a repair service means and cannot comprehend that. This can lead to distrust in repair services. Also, a working product cannot be guaranteed after repair, whereas a working replacement product always has a

100% guarantee of working (Svensson-Hoglund et al., 2022c).

2.2 Repair in emotions

Repair is not always seen as negative, and can bring forth a lot of positive emotions. Self-repair makes people feel empowered since in the process of repair, one develops new skills. It is a process that needs creativity and can be enjoyable, and when one succeeds it can lead to satisfaction by successfully having extended the product lifespan. Lastly, it gives responsible resource use which can lead to feelings of stewardship (Scott & Weaver, 2014). A successful repair can lead to another attempt on repair in the future and increases the individuals willingness to buy and pay more for repairable products (Svensson-Hoglund et al., 2022c). **A future attempt on repair is dependent on the positive outcome of past repairs. Repair can also bring forth a lot of positive emotions which influence the repair outcome.**

Another way of increasing these positive emotions that are linked to a product is to create memories, self-expression, since these create irreplaceable possessions. This can be done by making products so that they express the identity of the consumer, which can be triggered by product personalization through DIY-activities or mass customization for example. This will strengthen their emotional bond (Van Den Berge et al., 2020). **Personalization will create greater product attachment which will cause product lifetime extension.**

Takeaways Chapter 2

- The longer it takes to repair a product, both passive or active, the less likely a user is to continue or begin the repair.
- If the effort of repairing is the same as replacing or higher, in most of the cases users will opt for a replacement
- Expectation management and convenience of use is key in a potential design intervention.
- A trigger is necessary for an impactful design intervention.
- A future attempt on repair is dependent on the outcome of past repairs.
- Repair can bring forth a lot of positive emotions which influence the repair outcome.
- Personalization will create greater product attachment which will cause product lifetime extension.

03 Stuff

The second pillar that will be discussed is the stuff. This refers to things or physical components that are necessary for doing or completing a certain practice. In this case, these are the repair essentials, such as the tools, spare parts and the information, but also the design of the products itself. The questions that arise in this chapter are shown in Figure 11.

3.1 Repair Essentials

There are specific components that are crucial for repairs, referred to as the repair essentials. These essentials can be categorized into three main parts: spare parts, tools, and information. Each of these categories will be explored in this chapter.

The first category of repair essentials is spare parts. These can further be divided into general components, including diodes, transistors, and resistors. On the other hand, there are product-specific parts, such as the casing, motor, heating element or buttons that are specifically made for only that brand. The underlying problems for the product-specific parts are, that if they are available, which they aren't 46% of the time, they are sold for an unfair price in 20% of the cases (Roskladka et al., 2023b). This can be due to the fact that the parts are no longer provided by the original equipment manufacturer (OEM) when the products have gotten too old. This is why lots of DIY repair shops have to use aftermarket parts or they have to harvest components from broken devices, which can be unreliable or hard to get to (Sabbaghi et al., 2016). 3D printing could be a huge solution to this, although there are still a lot of difficulties regarding the digitisation of these spare parts, since there is little guidance on how to replicate a 3D-printed version of the original part (Van Oudheusden et al., 2023). This is not a problem for the universal parts that are used in the printed circuit boards. **Product specific parts are expensive and hard to come by.**

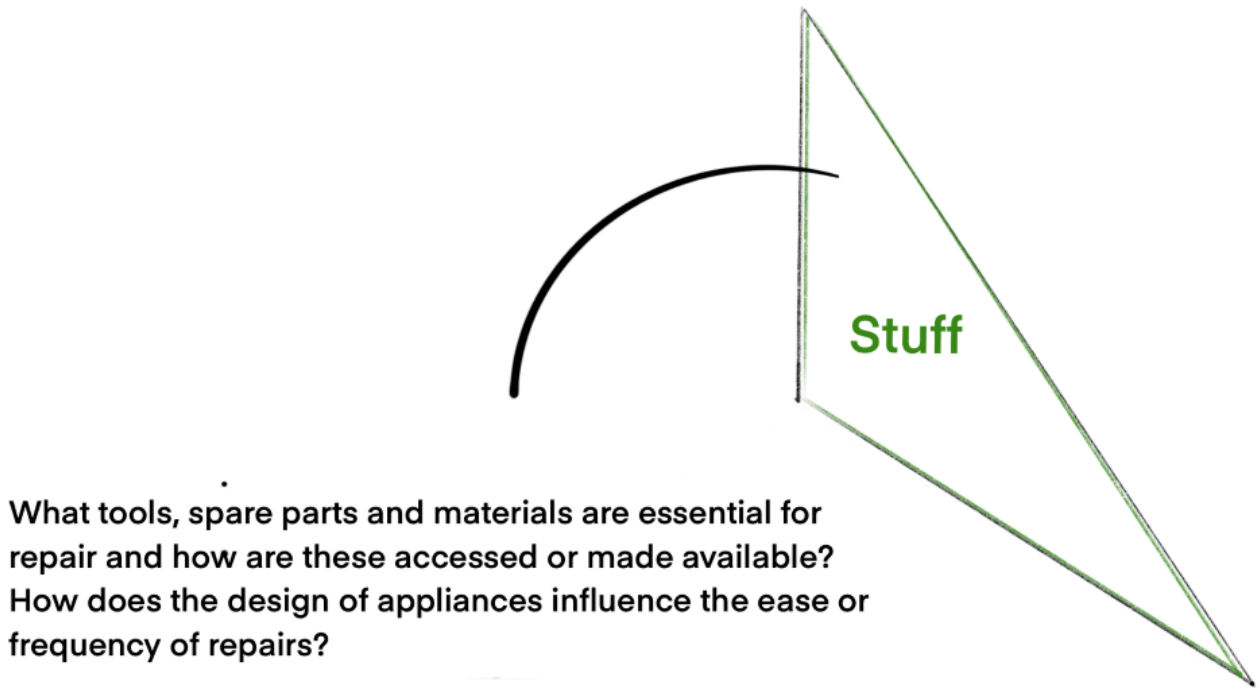


Figure 11: Stuff, the second part of the Practice Theory model

The tools to get into the product are the second repair essential.These tools are a screwdriver, an Allen-key, a wrench, pliers , a soldering iron and a multimeter. There is a whole array of screwdrivers that are necessary for electronics. These vary from triangular screws to Y-type screws and are described in Figure 12.

Figure 12: Screwdriver types and their openings (IfixIt, 2024)

However, these tools are in 55% of cases not efficiently designed. Users wish to have better magnetic grips to hold screws in place, they want to have screwdrivers that are adjustable in terms of length and angle or an opening tool made for fragile casings of products (Sabbaghi et al., 2016).

Since only 43% of consumers know how to use a soldering station and only 33% knows how to work a multimeter (Dangal et al., 2021) , it can be concluded that even a smaller amount of the general population has a soldering station or multimeter. The general person will need to buy this, before they can solve an electrical problem. **Consumers need a varied set of screwdrivers with different lengths for small household appliances for mechanical problems, an allen key, a wrench, pliers and a soldering iron and a multimeter for electrical problems (Figure 13). The last two need to be acquired in more than 70% of the cases.**

Thirdly, there is information, the access to it, and especially being able to find the right information. Information in a sense of DIY repair means either looking for guides on YouTube or Ifixit, trying to find service manuals either put online by the manufacturer or by a third party. These manuals, videos or guides can be challenging to come by. On YouTube and Ifixit there are so many guides to help you, but locating that exact fault can be a lot more difficult. There already needs to be a specific person that had your specific product and that specific fault. For service manuals it can be very hard to find, since many manufacturers do not upload these, or the consumer has to pay for them to see them. There is an overload of information, which makes finding the right problem for your specific product can feel like searching through a haystack full of needles trying to find the exact needle that you need. **Thus, the right information is scattered over the internet and hard to come by.**

Figure 13: Repair esssentials

3.2 Design of appliances

The design of appliances has a huge factor on how easy it is for people to diagnose faults that happen to them (Arcos et al., 2021). This is of course not the only thing that the design of products can give you. Before one can diagnose the fault, one has to get into the product itself without the possibility of breaking it, such as adhesives, snap-fits or soldered components. Even low quality materials can cause this same problem, due to corrosion, wear-and-tear or fatigue resistance. (Roskladka et al., 2023b).
When inside the product, it can appear to be one big block of materials, where well-functioning parts of products are not really detachable or accessible, or when there does not appear to be a logical connection between functioning parts of a product (Roskladka et al., 2023b).

Furthermore, a lot of parts can give users a headache as well by creating a very long and difficult disassembly process (Roskladka et al., 2023b). Well-designed products for repairing gave participants more information and guidance when they tried to locate faults, this guidance could be text-related clues or putting parts that work together on the same disassembly level. This can be things like safety instructions, or precautions related to electrical thermal or chemical risks. When this guidance was not here, visibility and accessibility were the biggest influencers of fault diagnosis. Another key factor is that products are easier to repair if disassembly is kept to a minimum and or easy to perform, meaning that there are no tools required for example (Arcos et al., 2021). **Guidance and a minimal number of actions to locate a problem increases the repairability of an appliance.**

Takeaways Chapter 3

- Parts are expensive and hard to come by.
- Consumers need a varied set of screwdrivers with different lengths for small household appliances for mechanical problems.
- Consumers need a soldering iron and a multimeter for electrical problems. These need to be acquired in more than 70% of the cases.
- The right information is scattered over the internet and hard to come by.
- Guidance and a minimal number of actions to locate a problem increases the repairability of an appliance.

04 Skills

The third pillar is the skills. Skills have everything to do with how competent an individual is. Are there differences between experienced and inexperienced users and how will that present itself in the repair process? Looking at this chapter the competency that is necessary for repair will be discussed. What skills does someone need to complete this practice and how can these be acquired? The questions that will be answered here are in Figure 14.

To start repairing, a consumer, either experienced or inexperienced, needs the tools discussed in Chapter 3.1. These tools are a screwdriver, an Allen-key, a wrench, pliers, a soldering iron and a multimeter. Most consumers can use these tools (>80%), except for the multimeter and soldering iron (<45%). **This means that consumers are better at solving mechanical repairs than electrical ones.**

When someone thinks of repair or wants to start, there are certain obstacles while trying to repair a product, one of these is the fear of further failures or a failed attempt at repair. This can cause them to replace the product before even having started the repair. Secondly, it is difficult to know beforehand how much time or costs the repair will take from you which can cause consumers to get lost during the repair or feel like it costs too much time or too much effort (Roskladka et al., 2023b). This, combined with a limited exposure to repair can lead to less propensity to repair and less repair engagement (Svensson-Hoglund et al., 2022c).

There are significant differences between experienced and inexperienced consumers. They are related to a lack of tools faced more by beginners, fear of damaging the product more, feeling that they can injure themselves more, not knowing how to take it apart more often than experienced consumers and having more difficulty with

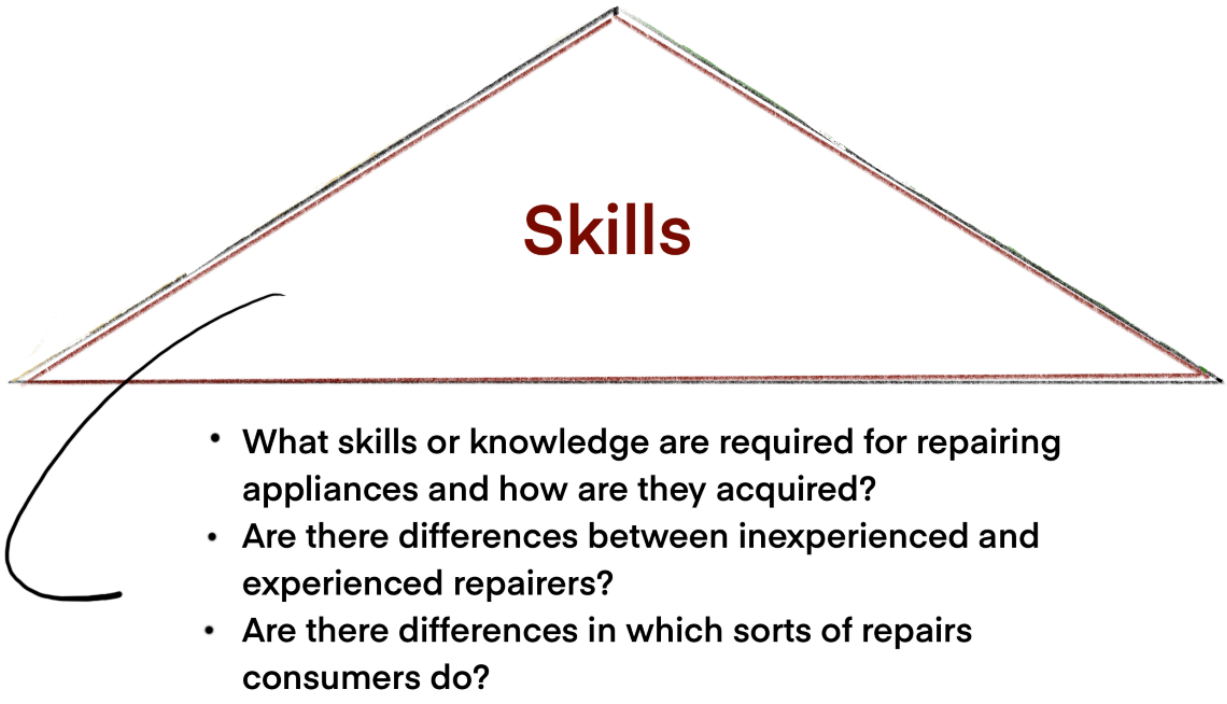


Figure 14: Skills, the third part of the Practice Theory model.

fault diagnosis (Dangal et al., 2021). Especially the last ones are interesting, since they have to do with strategy in how to take on a specific repair, as shown in Figure 15.

There are weak and strong strategies, a weak strategy is doing 'blind-search' where all the possible causes for breakage of the device are reviewed randomly. This is of course not the ideal strategy since there are certain components or connections that are more prone to failing, due to more interaction with the user or parts that need to sustain more heat, tension or electrical current. A strategy that is ideal to follow is the domain-specific strategy. Experienced users that use this strategy will look for possible causes based on historical information, looking for certain patterns or cues that they have seen before (Arcos et al., 2021). Users will follow the diagnosis steps described in Figure 16 and use different strategies based on their repair experience. So, more skilled repairers are likely to use strong search strategies. **Inexperienced users are prone to follow a weak or no strategy at all, since they have no habit of repairing. They also lack repair-specific tools and worry about hurting the product or themselves. Èxperienced users mostly follow a strong strategy, based on historical information.**

Takeaways Chapter 4

- Consumers are better at solving mechanical repairs than electrical ones.
- Inexperienced users are prone to follow a weak or no strategy at all, since they have no habit of repairing.
- They also lack repair-specific tools and worry about hurting the product or themselves.
- Èxperienced users mostly follow a strong strategy, based on historical information.

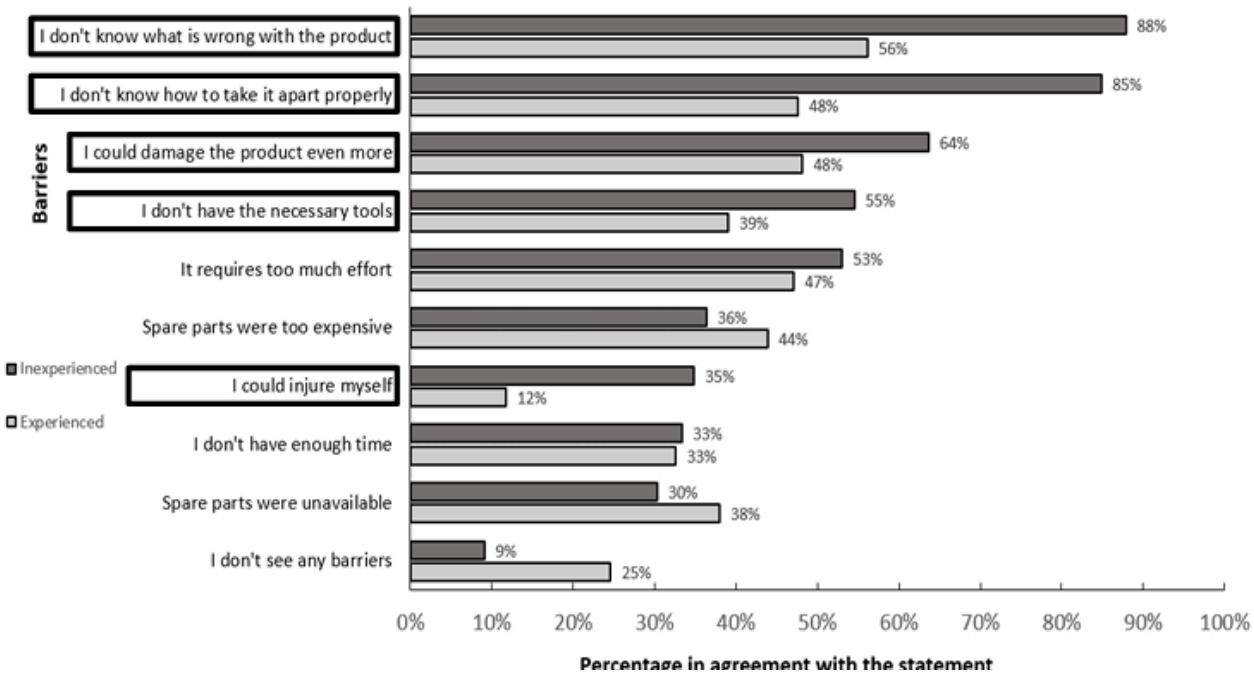


FIgure 15: Comparison between inexperienced and experienced users

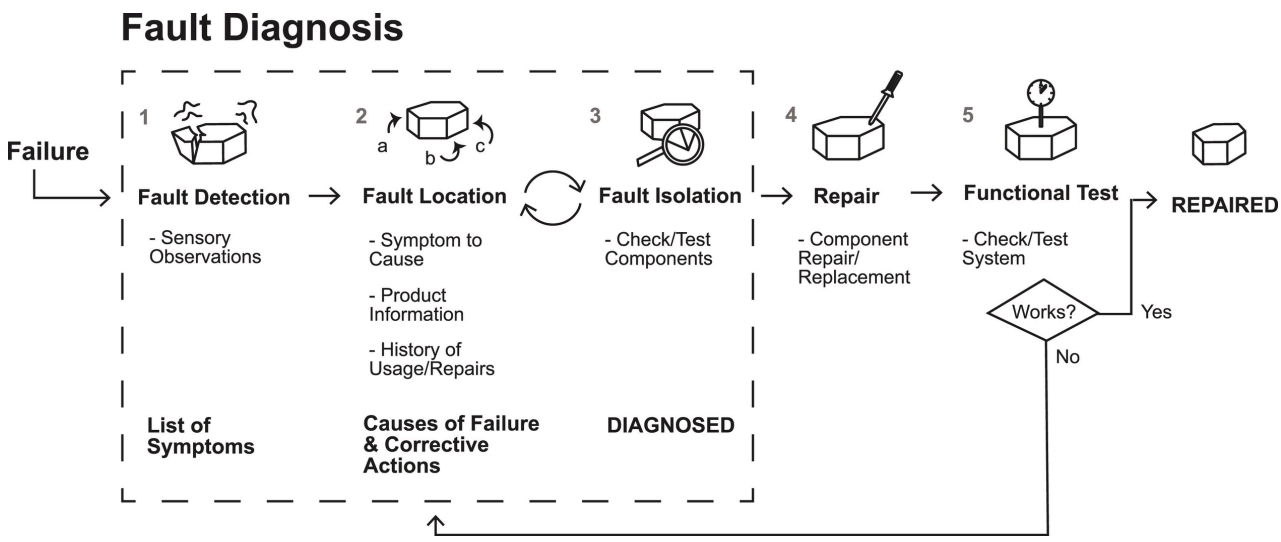


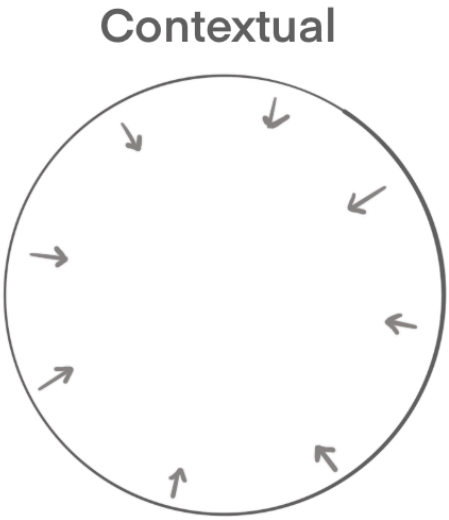
Figure 16: The schematics of fault diagnosis for consumers

05 Contextual

The last aspect of Social Practice Theory that will be discussed are the contextual factors. These encompass manufacturers, governmental policies and repair initiatives. What influence do these have on the pillars together, and on what factors more specifically? The questions that will be answered in this chapter are in Figure 17.

There are a couple of stakeholders that can influence the barriers and motivations perceived by consumers. One of these stakeholders are the manufacturers.
Manufacturers are a big influence in the repair sector. They can make special price promotions to lure consumers into buying new products, or attract them with trade-in-discounts. Secondly, they can make the actual repair more difficult with proprietary parts, such as specialized types of fasteners, making spare parts unavailable or very expensive to consumers and furthermore, new technologies can make the use of former models obsolete, such as stopping software for certain models of laptops or smartphones or a better energy efficiency (Roskladka et al., 2023b). Products can also be manufactured for a predetermined time by integrating electronic components that are made to last a shorter life cycle than that of the whole product or have components that are impossible to substitute (Roskladka et al., 2023b). As a positive, they could facilitate a temporarily loaned device to facilitate the repair by the consumer (Svensson-Hoglund et al., 2022c). Sometimes manufacturers forbid unauthorized repairs by DIY repairers and do so through security based watermarks and other tamper-resistant hardware (Roskladka et al., 2023b). **In general, manufacturers make the life of the consumer more difficult by giving products a set end-date. Secondly they make repair more difficult through proprietary parts and unavailability of spare parts.**

Secondly, the government and their policies have a huge influence on repair practices. For example, the Right to Repair can be a big motivator for consumers, since it can push legislation to help consumers repair their devices more easily. This will be done by making demands that products should be technically repairable, by making sure hat manufacturers inform consumers how to repair products that should be repaired by



How do repair costs compare to replacement costs and how does this economic dynamic shape practices?
How do warranty policies, planned obsolescence and manufacturers affect repair behaviors?
What role do repair cafes, workshops, maker spaces or community initiatives play in promoting or discouraging repair practices?
How do governmental policies, such as right-to-repair laws, influence the prevalence of repair activities?
How do manufacturer's practices (e.g. proprietary parts, repair restrictions, liability clauses) affect the ability to repair appliances?

Figure 17: Contextual factors of the SPT model

consumers, by introducing a platform for repair that connects consumers with repairers and that makes sure which ones deliver quality repairs and by giving information about repair of products during sale, such as a repair label (Europese Commissie, 2023). How they will inform consumers and demand technically repairable products is through the Ecodesign for Sustainable Products Regulation (ESPR) initiated in July 2024. These are a set of requirements necessary for almost all categories of physical goods. The ones that are specifically important in terms of repair are: the improvement of product durability, visibility, upgradability and repairability, being transparent about hazardous substances that limit circularity and improving the availability of information on product sustainability (Ecodesign For Sustainable Products Regulation, 2024). This will make a big difference in the repair landscape, since there will be more information available to the consumer, but every manufacturer will do this in a different way. Will this be easier to find for the end user? **The RTR and ESPR make information about the product more accessible and the way to act on it from a producer's perspective.**

The cheapest and most widespread repair initiative is the Repair Cafe. This is spread over a lot of countries and has over 3500 locations worldwide (Repair Café. (z.d.)). However, the target group is more 40+ than relatively younger people. This has to do with the fact that you need to have a quiet life, because otherwise it ends up last on the priority list (Appendix A). Maker space is a sort of DIY hub that has tools and appliances for collaboration for small individual projects and startups. Lastly, the DIY repair shop is also an option, although diagnosis will put a huge strain on the costs and since it is carry-in takes a lot of time for the consumer as well (Kort et al., 2021) Doing it by yourself completely or get help from a handy neighbour can always be a last resort. **All in all, there are not enough of these repair services, they have unsuitable locations (Roskladka et al., 2023b), or the target group does not prefer them.**

The primary reason for the choice between repair and replacement might be the cost (Scott & Weaver, 2014).

If the repair becomes too high in comparison with a replacement product, the latter is the most obvious choice (Dangal et al, 2021). **The estimated percentage of this lies around 18-35% of the price of a replacement product depending on the product type (Fachbach et al., 2022b).**

Takeaways Chapter 5

- Manufacturers make the life of the consumer more difficult by giving products a set end-date.
- Manufacturers make repair more difficult through proprietary parts and unavailability of spare parts.
- The government makes information about the product itself more accessible and the way to act on it through ESPR and RTR.
- There are not enough repair services, they have unsuitable locations (Roskladka et al., 2023b), or the target group does not prefer them.
- The estimated percentage of the cost of repair lies around 18-35% of the price of a replacement product depending on the product type

06 User research

In this chapter, we will examine the research focused on the designated target group. We will explore the emotions that emerge during the repair process, determining which feelings hinder and which ones facilitate it. This section will apply all the elements of the SPT model in practice with the identified target group (Chapter 1.2.2). We will begin by discussing how the test was structured, followed by a discussion of the insights gained. Finally, we will address the issues that lead to additional challenges throughout the repair process chain.

6.1 Set-up

With the selected target group I performed research and used Sensitising Booklets (Appendix B) to do this. These booklets come from a method known as sensitising (Sanders & Stappers, 2012) and are used to get participants familiar with a certain topic while getting a lot of good qualitative feedback.

Six participants that were selected from my close network, mostly containing my family or friends, had to choose a product that was broken to repair at home. I did not give them instructions to reach out to anyone that could help, like a family member, friend, repair cafe or a professional repairer, but did mention they could. I followed the ''practice theory'' principle to make it as close to reality as possible. This would be to not give them any more than they already had in their own environment. In this way, you can clearly see the underlying obstacles that arise when trying to repair something yourself. As a researcher, you try to always follow your own models, but in this instance, the motivation of repairing something yourself is not there since I asked to repair a product. They did not make a choice if they wanted to repair or not.

I will use in-depth interviews (Boyce & Neale, 2006) with each of my participants (Appendix C). This will get me a lot more information from each participant and is also logistically easier to plan. In-depth interviews is an individual interview where I will review the sensitising assignment and ask questions based on the booklet to gain even more insights into the participants' barriers and motivations. Furthermore, in these interviews that came after the sensitising, I asked them if they would have repaired the product if I hadn't asked them. They had three weeks to repair the product (to see how far they could come), to report and to send back the booklet by mail (if necessary).

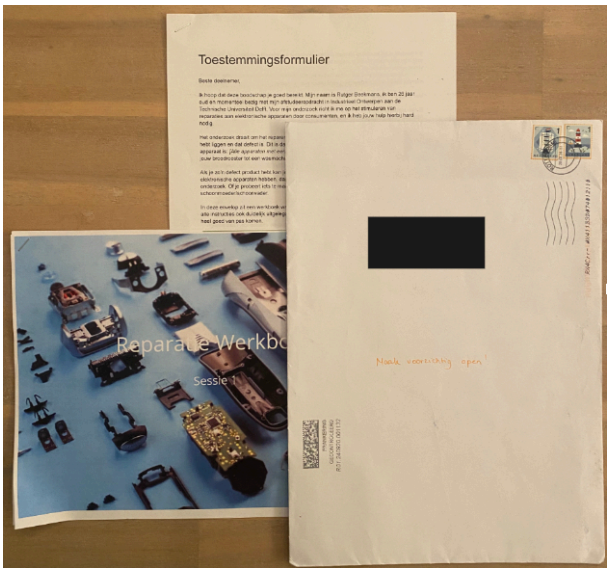


Figure 18: The sensitizing booklet kit

6.2 Barriers and drivers from user research

To figure out if certain barriers and drivers can be grouped on characteristics in the whole repair journey (Figure 19), themes were created. This was done by grouping certain factors that had an overhanging subject. Furthermore, certain interesting barriers, drivers and insights will be discussed in more detail in Appendix D. These are highlighted in cyan. The factors

that came from my literature research are highlighted in yellow. The themes are described in Figure 19. These are intertwined with the pillars of SPT. Factors that are not influenceable in the design intervention are 'Emotions towards product' and 'Design of Appliances', which are orange in Figure 19. The emotional value, bad design and all the characteristics that come about with certain specific products is not something I can design for. These are constants that vary for every product. I can for my design think of certain lines of products, but it is out of my hands if you can look inside a product just because it happens to have a transparent plastic outside (Appendix C: Depth-interview 2). Another one is the social norms, this is based on what a person values and has unconsciously learned during his/her whole lifetime. This is not influenceable in the design intervention either.

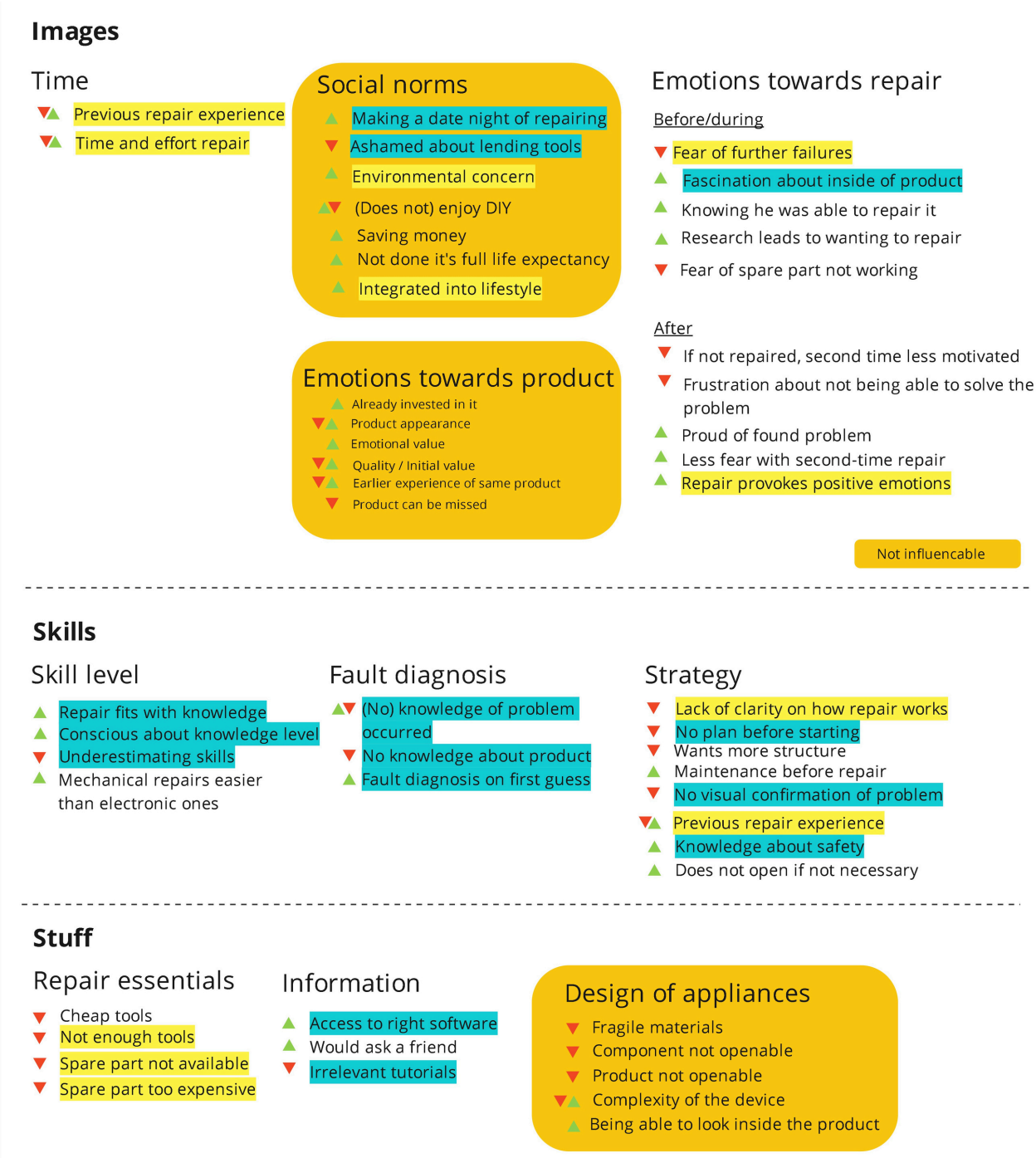


Figure 19: Barriers and drivers found in user research

Like discussed in the literature research (Chapter 2-5), the pillars of SPT follow the factors that influence it. Images are divided up into time, social norms and the emotions towards repair. Stuff is split up into the repair essentials, information and the design of appliances. Skills are divided into the skill level, fault diagnosis and strategy. There are some interesting factors to take into the design process.

Firstly, the repair essentials, if a participant does not have the right tool to open up or disassemble a certain product, the repair stops completely. Knowing beforehand what someone needs is essential, since this can prevent a major deception. Seeing that someone has done the repair already and knowing that your problem is indeed repairable is important taking into account that finding the right source doesn't take ages. **A lack of tools can completely stop the repair process and a lack of useful information will hinder the repair process.**

Secondly, the skills. Knowing the right skill level for participants to take on a task that they are able to do is important as well. Otherwise they might stop due to frustration and based on Chapter 2.1.2 the outcome of past repairs influences future repairs. Fault diagnosis is, like Chapter 4 discusses an experience based skill, just like all the strategy components. The important thing is thus, to make inexperienced repairers think and act like experienced ones. **Correct fault diagnosis is possible by creating a plan and a certain strategy necessary for a positive repair experience.**

Lastly, the images are important as well. The time factors are discussed in Chapter 1.1 which state that a repair journey needs to be transparent and participants need to know what they can expect beforehand. For the emotions toward repair, they can be divided into before/during and after repair. For after repair, it again can be said that the outcome of past repairs influences future repairs. For before/during, as stated in Chapter 2.1.2, it is important to highlight positive emotions, such as the fascination of seeing the inside of a product, and to eliminate or decrease negative emotions, such as the fear of further failures. The last one will be done by guiding participants through the repair. **Highlighting positive emotions during the repair process is necessary to create a positive repair experience.**

6.3 The repair journey

In Figure 20, the whole journey with all the obstacles and motivations is displayed in a journey map. This is a way to map out the steps a person goes through when they interact with a product or service. It's like creating a clear timeline of what happens, where things might get tricky, and where there are chances to improve. By laying it all out like this, you can spot key moments and issues that help shape better designs (Endmann & Keßner, 2016). I used it here to see which barriers and which drivers show up at certain moments in the repair process.
Furthermore, I used it to see which initial problems can cause more problems along the chain. This is done by highlighting several factors in the first couple of steps along the chain and putting dots after problems that appear later in the chain, caused by these first factors. If a colour highlight is connected with a dot of the same colour, there is a definite connection. It stands out in Figure 21 that a lot of problems come from the fact that participants do not know where in the device a problem comes from. These cause a lot of problems further along the chain, such as frustration, underestimation of skills, no knowledge about procedure, different problems than expected and mostly a faulty self-diagnosis. **The biggest problem for a negative repair outcome is a faulty diagnosis, since it will show up all along the repair chain.**

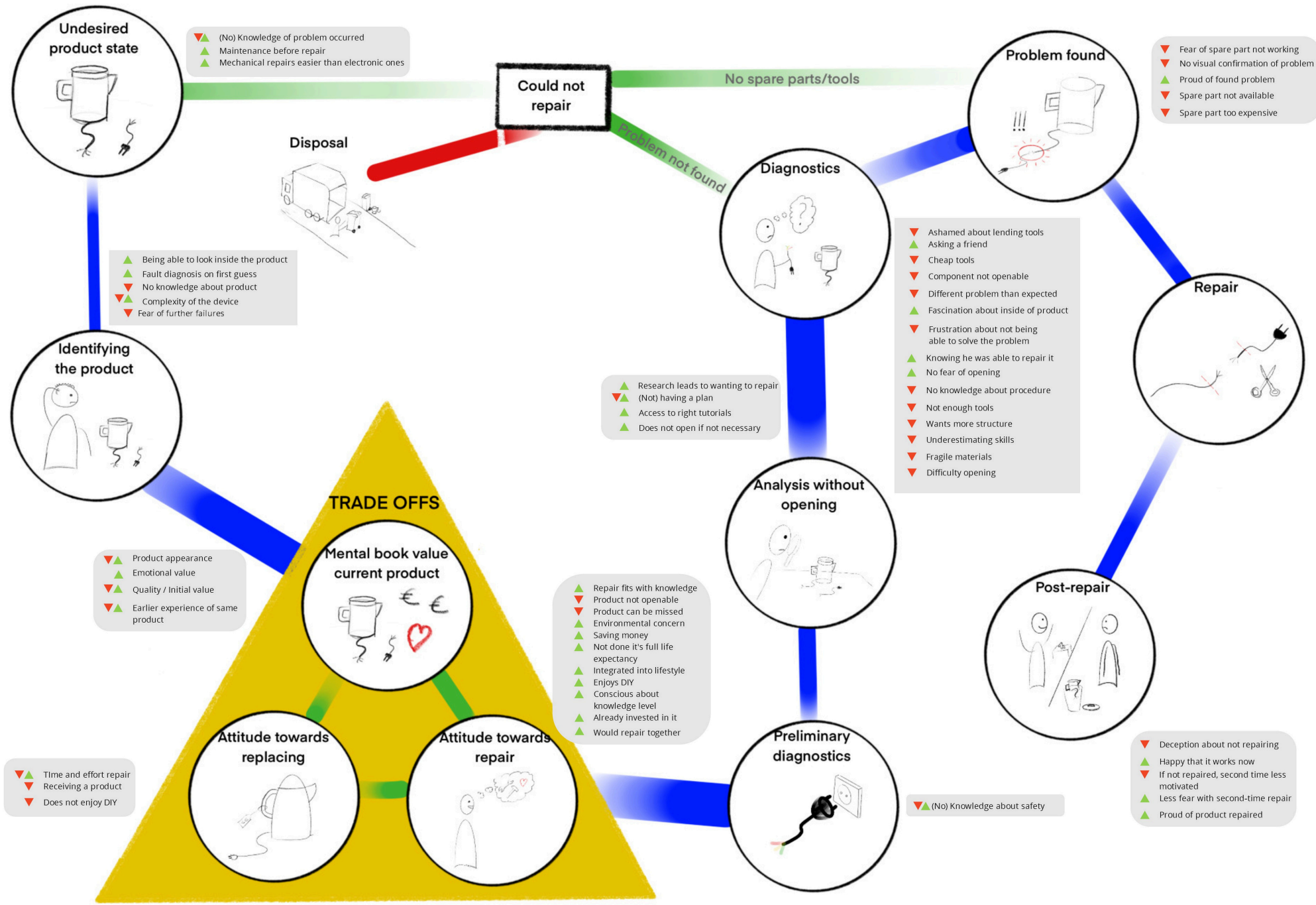


Figure 20: The repair journey

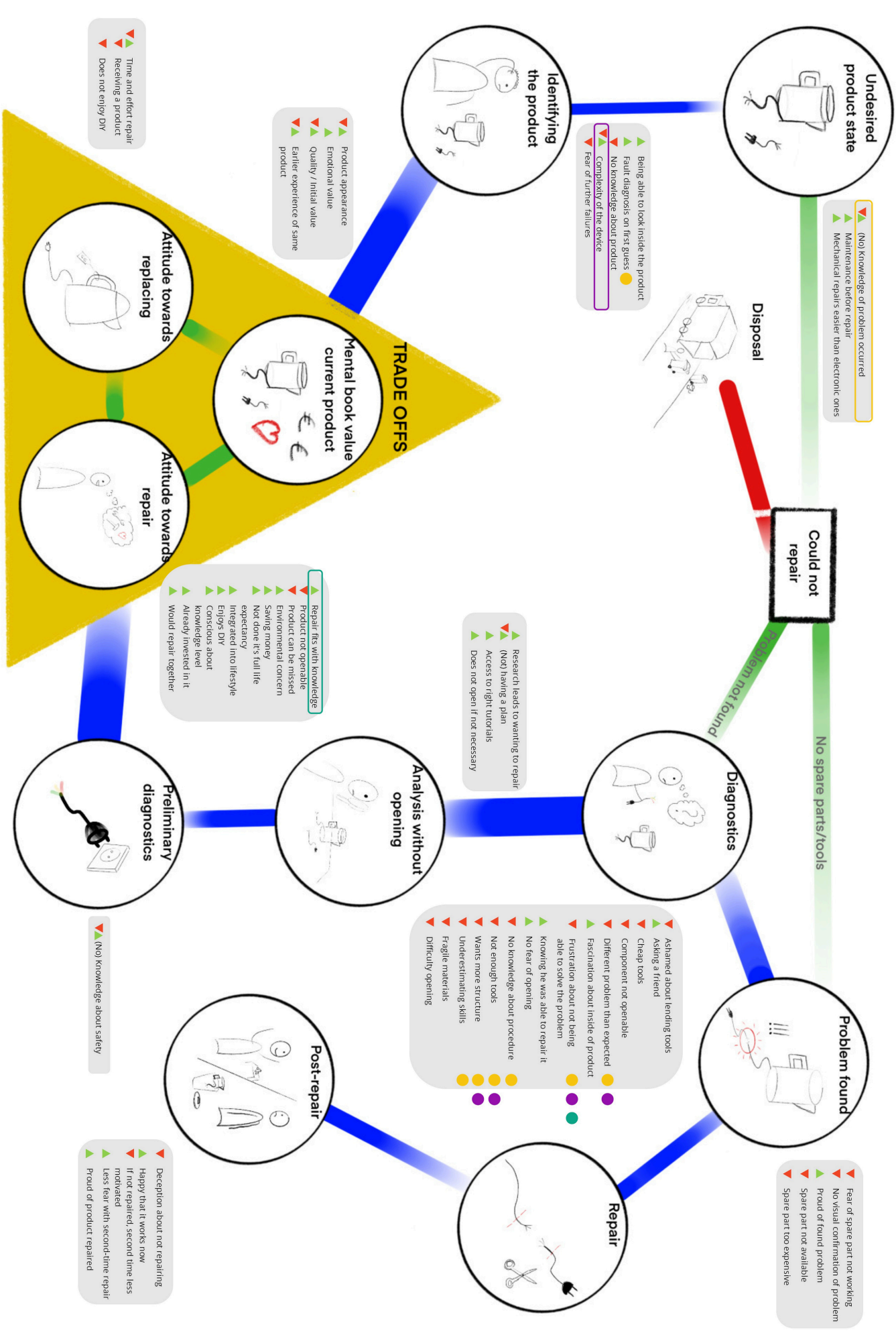


Figure 21: The repair journey with problems along the chain

Takeaways Chapter 6

- A lack of tools can completely stop the repair process
- A lack of useful information will hinder the repair process.
- Correct fault diagnosis is possible by creating a plan and a certain strategy
- Highlighting positive emotions during the repair process is necessary to create a positive repair experience.
- The biggest problem for a negative repair outcome is a faulty diagnosis, since it will cause further problems all along the repair chain.

B. Define

The overall aim of this thesis is to stimulate consumers to repair electronic products in or around their home environment. With the results of the last five chapters, this very broad research goal was specified in the define phase. Chapter 7 presents how this will be brought to a design direction.

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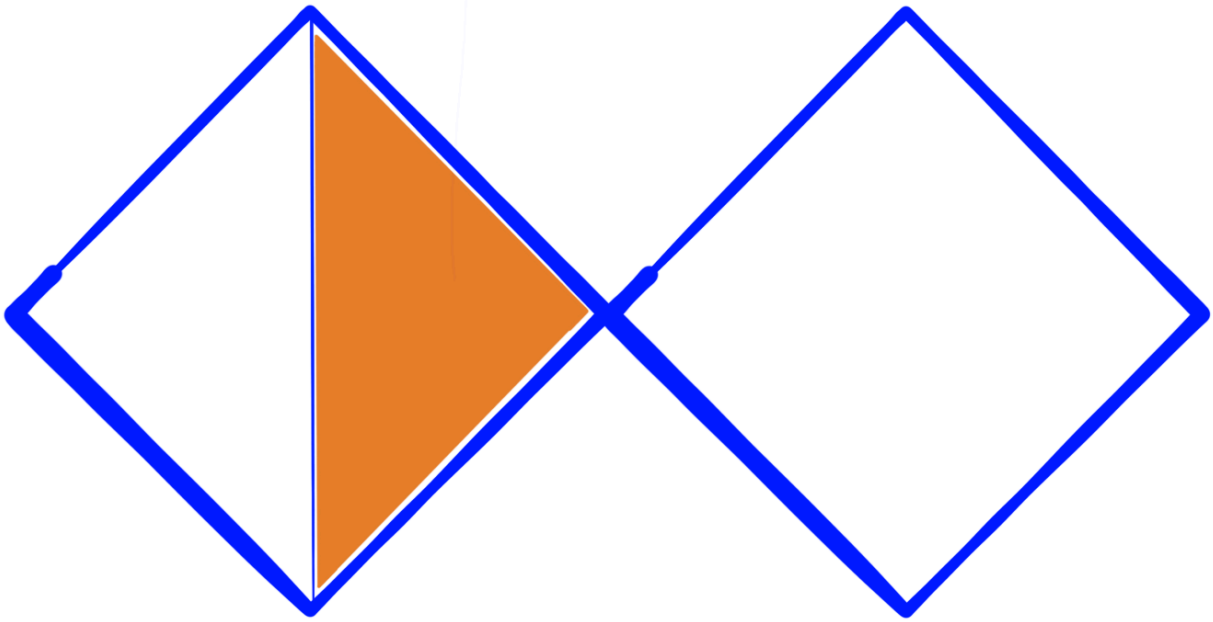

Figure 22: Define, the second part of the double diamond model

07 Design Direction

The overall aim of this thesis is to stimulate consumers to repair electronic products in or around their home environment. With the results of the last five chapters, this very broad research goal was specified in the define phase. Chapter 7 presents how this will be brought to a design direction.

7.1 Design statement

Like stated before, based on the discover phase, the following design vision was formed:

To design a concept service to stimulate highly educated 18-34 year olds before, starting and during repair on small household appliances by providing physical handles, creating guidance and managing expectations.

7.3 Design wishes and requirements

In Chapter 7.1, a global design goal was formed that the design intervention should adhere to. The design requirements and wishes are there to go more into detail of this intervention and to see what is necessary and beneficial on a more zoomed-in level. These requirements are arranged from one to five with one being the most important requirement and 11 being the least important.

These requirements come from the influenceable takeaways from chapter two until six.

Requirements: the design should:

1. Increase motivation of the consumer to start repairing
2. Provide consumers with
    a. a strong strategy for fault diagnosis, based on historical information
    b. the right information needed for repair, such as what to look out for (visual confirmation) and how to repair this issue.
3. Give consumers the necessary tools needed for repair
4. Provide an estimation about the time, the costs and tools needed before starting repair
5. Give individuals knowledge about how the tools work that they will use
6. Focussing on positive emotions during the repair process
7. Make it convenient to use for consumers

Wishes: the intervention could:

1. Use existing repair initiatives or recommend them
2. Draw on the foundation that is set with the ESPR and the RTR
3. Keep under the threshold of 18% of the cost price of new products
4. Have a feature that can be used for personalization, since it can increase product attachment
5. Take into account the repair experience of the individual
6. Keep the amount of time (both passive or active) as low as possible
7. Increase fascination of seeing inside a product

C. Develop

The Develop phase marks the beginning of the second diamond. During this stage, I will generate a multitude of ideas and refine them down to a single concept that I will then further develop. Further on analyses will be conducted, engaged in co-creation, and additional methods will be employed to validate whether the concept is progressing in the right direction.

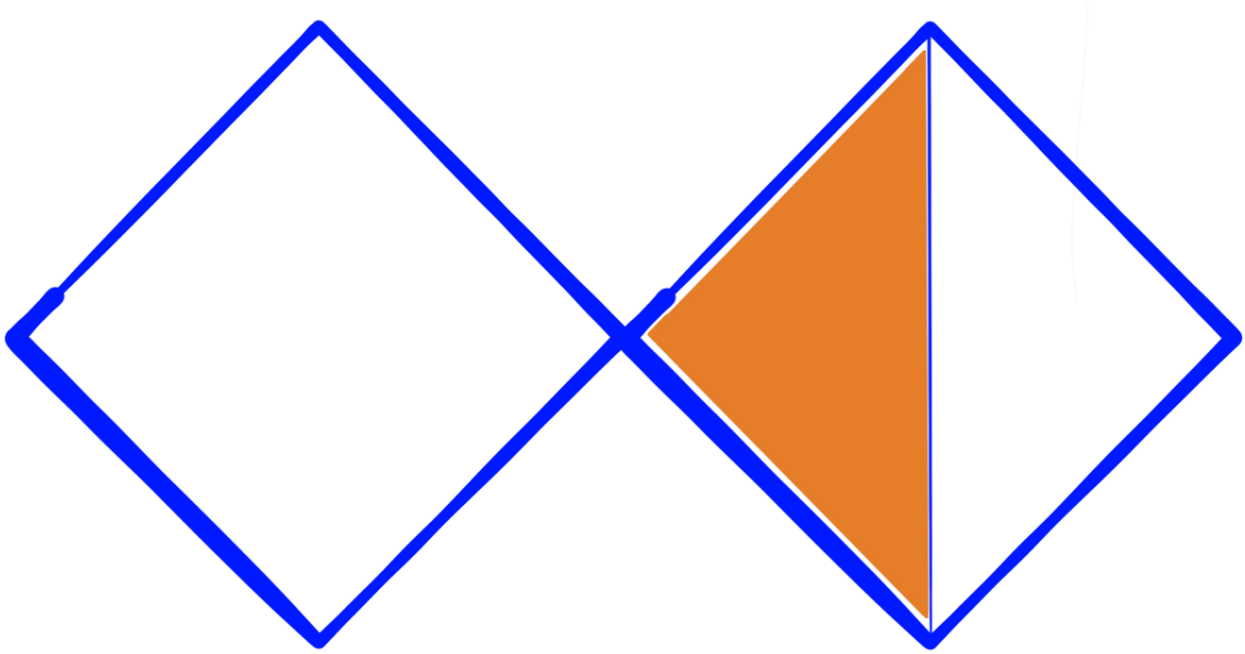

FIgure 23: Develop, the third part of the double diamond model

08 Developing concepts

In this chapter, many ideas will be generated which will then be selected by a C-Box to capture innovative and feasible ideas. These ideas will then be selected using the requirements and wishes of the design goal. From there one concept will be chosen to be further iterated on. The first ideation was done by myself and to create even more ideas a co-creation/brainstorm session was conducted with some students from IDE as well. The Brainwriting model from the Delft Design Guide was followed (van Boeijen et al., 2013). Initially, small ideas were generated and after that, more in-depth concepts were created through these ideas (Appendix F)

All these ideas were put in a C-box (Tassoul, 2006) to cultivate only the innovative and feasible ones. Out of these ideas, three valuable concepts arose, with two having a variation on them, which makes five concepts. These will be discussed in the next paragraphs and thereafter the best one will be selected based on the design criteria, namely the wishes and requirements.

8.1 Concepts

The first concept is BIY - (IKEA Version), which means Build-It-Yourself. The product you get, will be received in a sort of IKEA building package, which you then have to build yourself. In this sense, the person knows how to assemble the product and through that experience also has the knowledge to disassemble it to see if something is broken. The way to come to each independent part is described in the product itself. The benefit of this is that, by building it themselves, people will understand how it's built and how the parts are connected. Critically this means they will have an understanding of how to disassemble when necessary.
However, a drawback of this concept is that consumers and the company will pay money for doing more work and also with the way products are designed now, as discussed before in Chapter 3.2, I do not necessarily see this as viable. This is stated in Figure 24.

Build-It-Yourself

Ikea building kit (1)

- you put it together yourself before you can use it
- creates the trigger for people to know it can be taken apart
- makes people know the sequence of steps before they get to the mistake

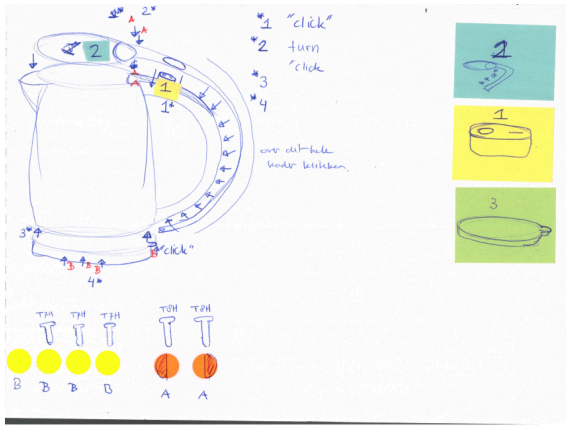

Figure 24: One pager Build-It-Yourself (IKEA building kit)

The second idea is the BIY - (Diagnostics). This offers users help with the actual repair, by finding the electrical issue and resolving it. This will give the user instructions on where to place the multimeter to see if a component is broken. This will help people in figuring out how to actually test and repair their own product. There are no tools that go along with this kit which might make purchasing it more difficult which in turn makes the idea less convincing. To make it more viable, this idea should be combined with tools. This is stated in Figure 25.

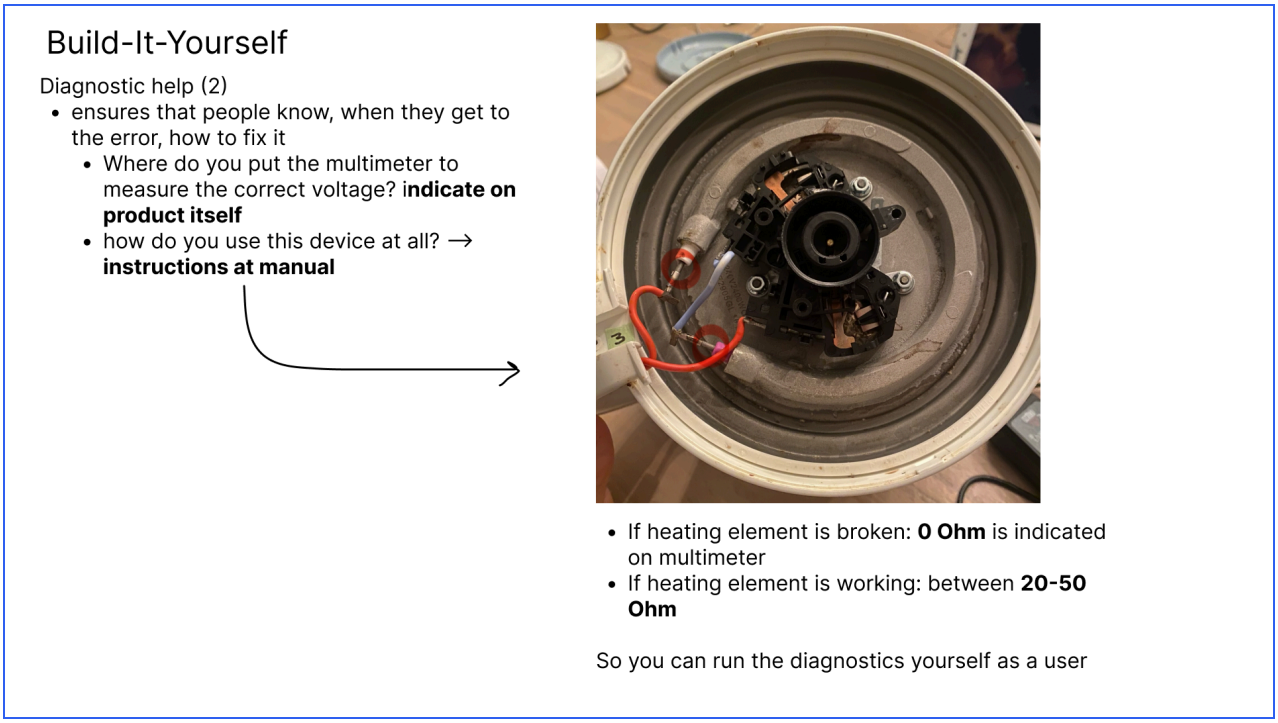

Figure 25: One pager Build-It-Yourself (Diagnostic help)

The third concept is the Electronic Survival Kit. This is a package that has all the necessary ingredients to try out repairing the electronic components of small household appliances. This includes a soldering station, tin, a multimeter, a set with specific screwdrivers and other tools. It would be sent to your home after you've made a deposit. This deposit will be returned to you provided the kit is returned and everything is in working order following a check by GAMMA. The problem with this kit is that checking already costs a lot of manual labor, so hire will be quite expensive relative to buying a new product altogether. This is stated in Figure 26.

Electronic Survival Kit

Ingredients

- Toolkit for repairing electronic devices for hire components: multimeter, bit set, soldering tin and soldering iron + possibly electronic spare parts
  - Explanation of how these devices work
  - Introduction of how to use them
  - manual with videos + Qr codes
    - How to see what is broken (visual cues)
- Deposit + home delivery
- Small contribution for borrowing

Figure 26: One pager Electronic Survival Kit

The fourth concept is the Scan-AR, this gives valuable insights when there is a need for repairing or even when there is not. It should sensitize people to be more aware that products can be opened and repaired so that when they break, there is a trigger to repair. The consumer scans a QR-code and through this, reaches a page with information on the components that are prone to failure in certain products. Additionally, it gives the user a strategy on how to repair these components, the tools you might need and how much it might cost. This makes it easier for people to repair when it comes to that. How it works is stated in Figure 27. The problem might be that people will not actually scan the QR-code with their phone. This is something that needs to be very thought-through.

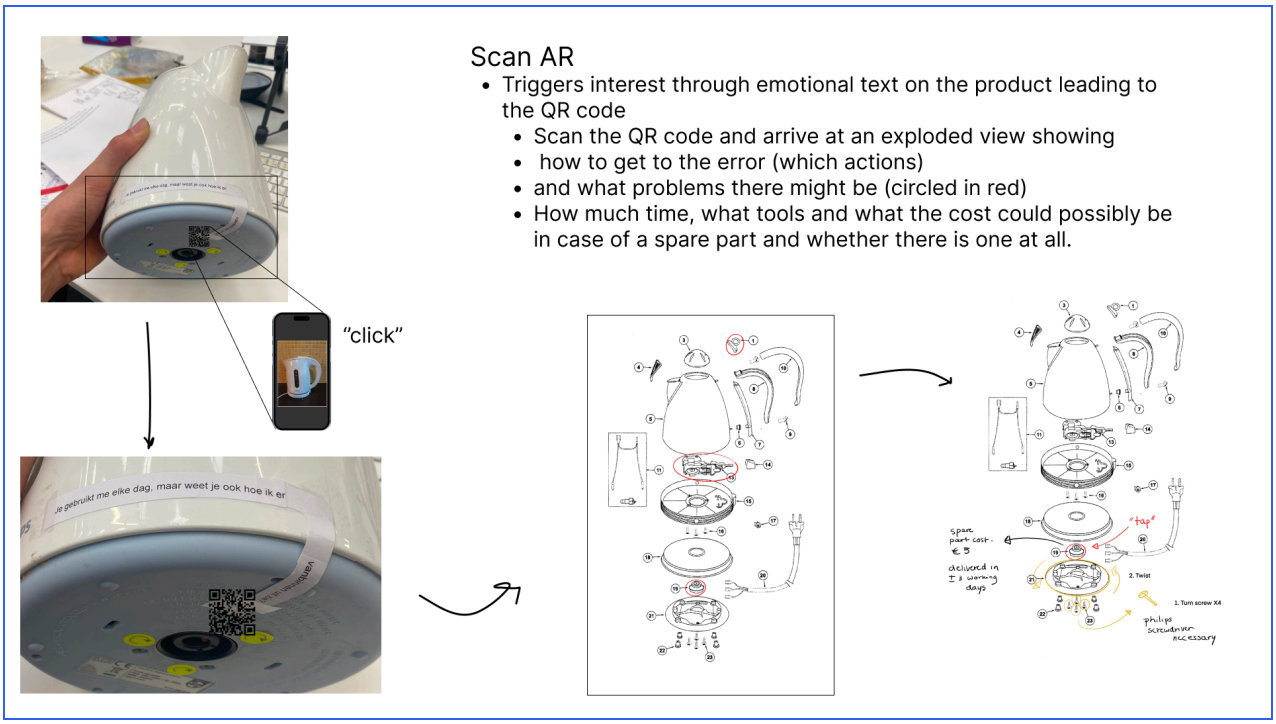

Figure 27: One pager Scan-AR

The fifth concept is Fold-out-art, a variation on Scan-AR. It works the same as Scan-AR, but presents the information in the QR-code as a fold-out version of an exploded view that the consumer gets in the box with their product. It triggers the consumer to use it due to its playful way of folding. This will create a sort of intuitive disassembly map of how users get to a certain part in a specific product. This is stated in Figure 28. The problem with the box is that people need to keep it until the warranty period comes to an end and then they need to know to use this concept when the product actually breaks. Something needs to be designed to overcome this issue.

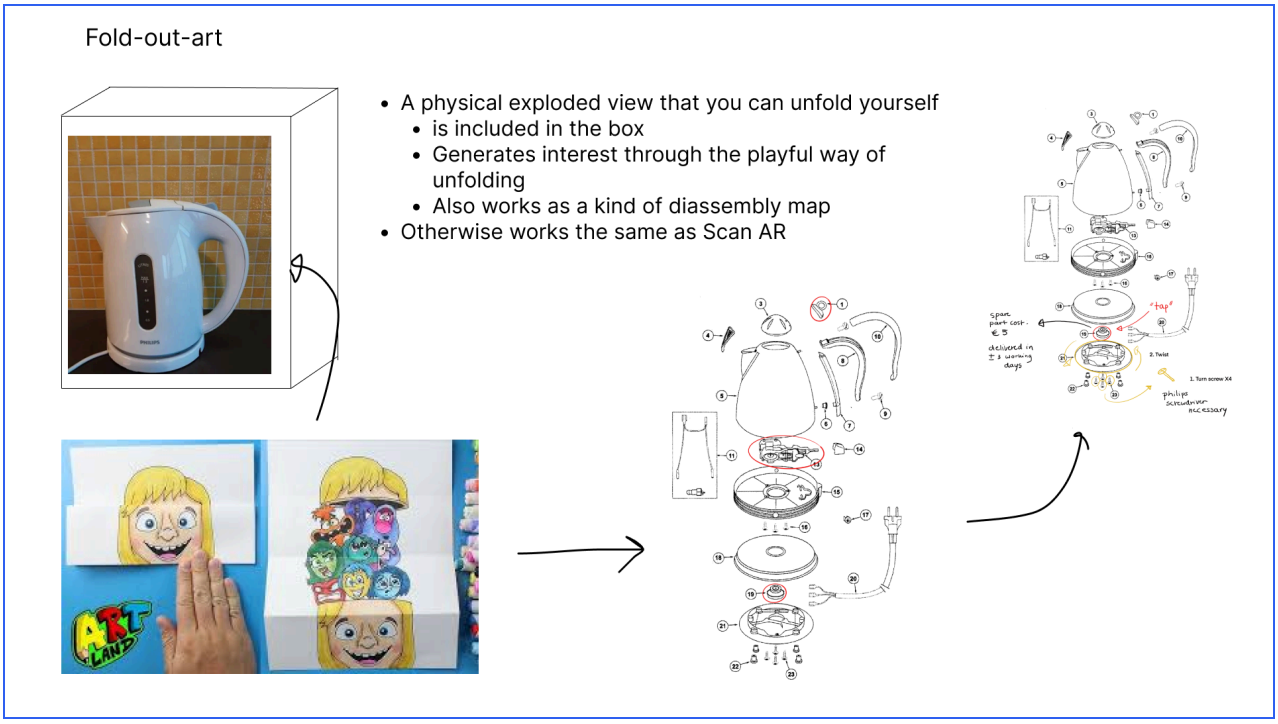

Figure 28: One pager Fold-out-Art

8.2 Concept selection

The concepts mentioned above were all compared on the basis of the Design Requirements and were created in Figure 29. The Harris Profile (van Boeijen, 2013) method was used to do this. Like stated in Chapter 7.2, the requirements are stated from most to least important.

There is not one definitive concept that is the best. Therefore, it was decided to combine several positive elements from different concepts. Firstly, the final concept uses the trigger (1) and strategy for fault diagnosis (2A) of Fold-Out-Art. This works since the trigger can be helpful in making the user want to start repairing and getting to the assessed fault in the product. However, how it would present itself after the warranty period is something that should be designed or worked around. It is not reasonable to expect consumers to keep it for 2 or 3 years and then remember where it was and how to use it. Secondly from the electronic survival kit concept it should include information on the tools needed for repair (5) from the Electronic Survival Kit. Thirdly, the visual cue feature (2B) from the BIY Diagnostics is used. This will help you diagnose if a component(s) are broken and how to repair them due to the precise manual which clearly explains how to test and repair it. Demand (6) and (7) are dependent on how all these features will work together and cannot be gotten from a single concept (Figure 30).

The final concept is called Puzzled. How it works is laid out in Figure 31. The final iteration of this concept will be explained in Chapter 10.

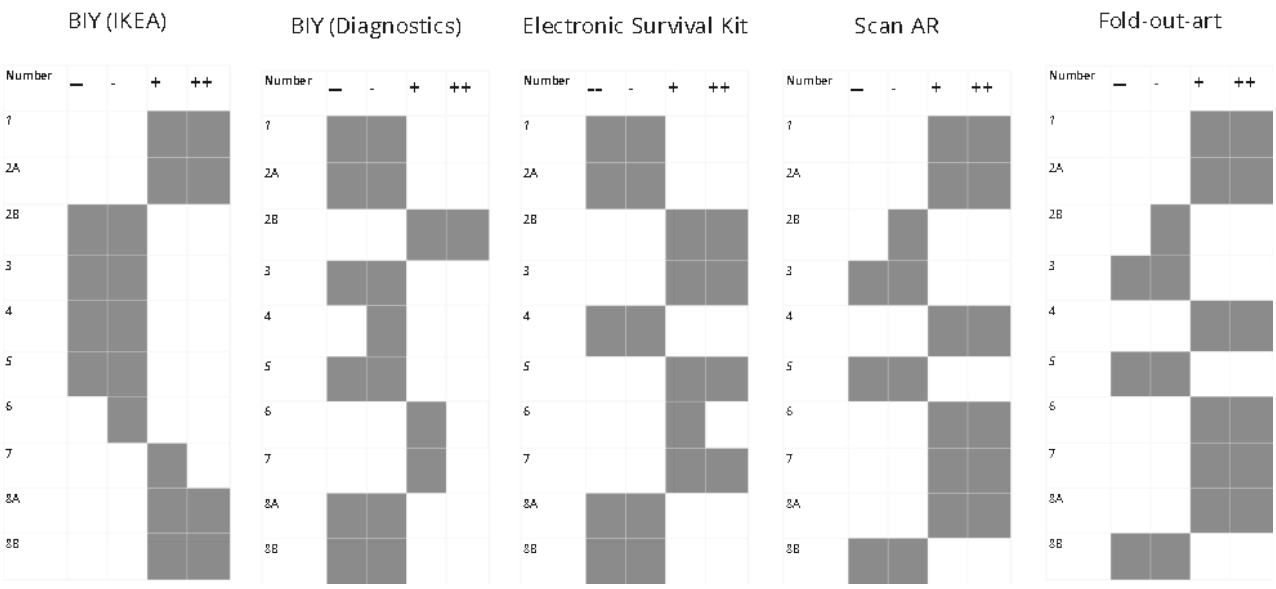

Figure 29: The concepts compared in a Harris Profile

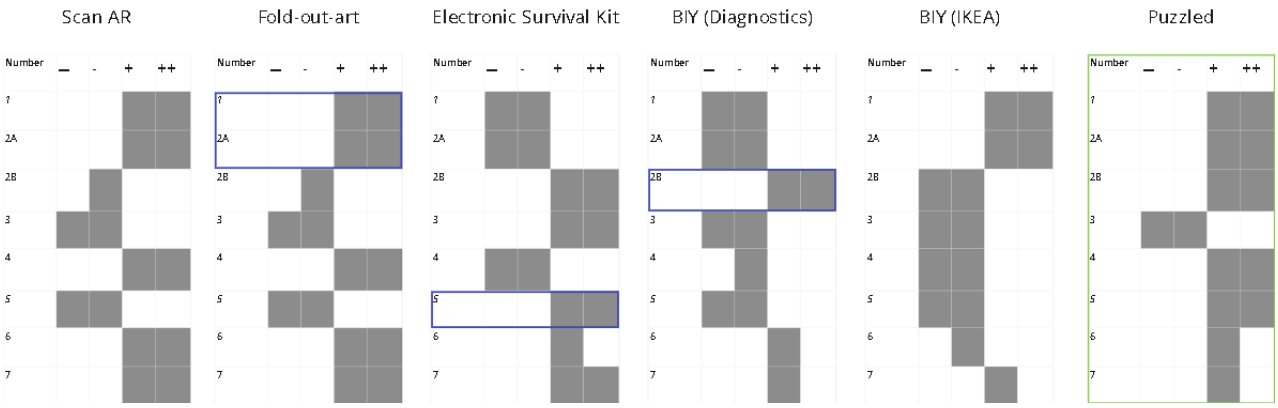

FIgure 30: The concepts + the final concept compared in a Harris Profile

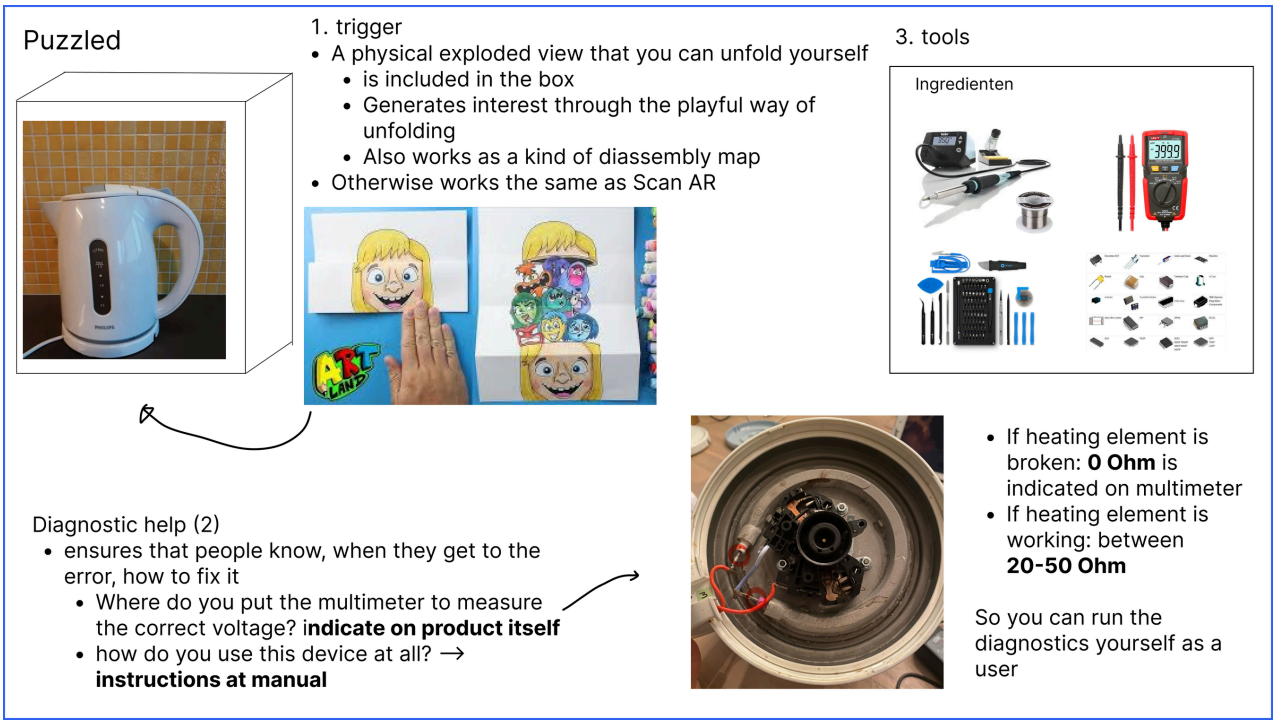

Figure 31: One pager Puzzled

D. Deliver

In this part of the double diamond, the focus will be on delivering a holistic view of the final concept, how it is validated, what can be concluded from this validation is which steps need to be taken to take this design to the next level and implement it in real life. This is also the final part of this report.

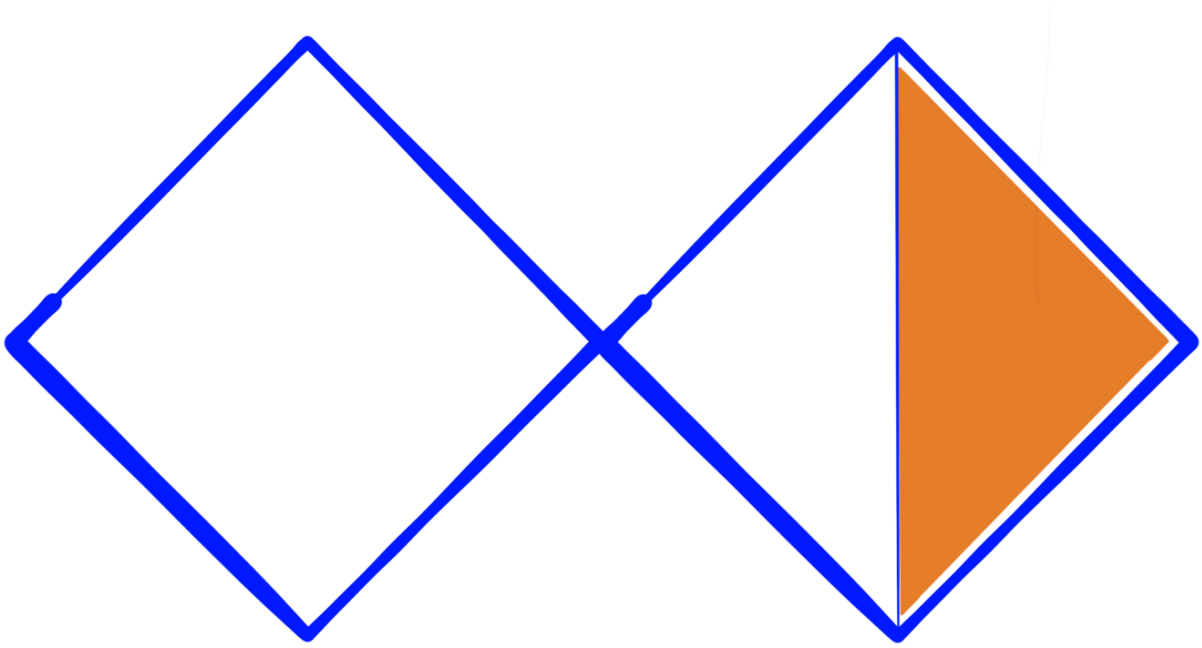

FIgure 32: Deliver, the fourth part of the double diamond model

09 Final design

How this concept works is shown by the different illustrations of this storyboard (Figure 33). Firstly, someone donates a small household appliance to the Rataplan. Then Rataplan takes it in and checks it to see if it is repairable. After that, that person makes a building package, which includes a package or box (Chapter 9.1.1), the frame, a broken but repairable product, the necessary tools and in some cases a spare part. The frame consists of a repair manual that will be discussed in Chapter 9.2. This package will then be sold in the store where somebody can purchase the package as a gift to someone who they can repair it with. They also have the option to buy the product online and have Puzzled sent to their home, although this will add transportation costs to the product. The person that received the gift, can hang the frame on the wall as a memory of that evening.

Not only how it is used, but also, why it is introduced (Chapter 9.3.1) and if it is feasible (Chapter 9.3.2) are important and will be included in this chapter. Which product I chose and why I chose it can be found in Appendix G. How I got to this final design can be found in Appendix H.

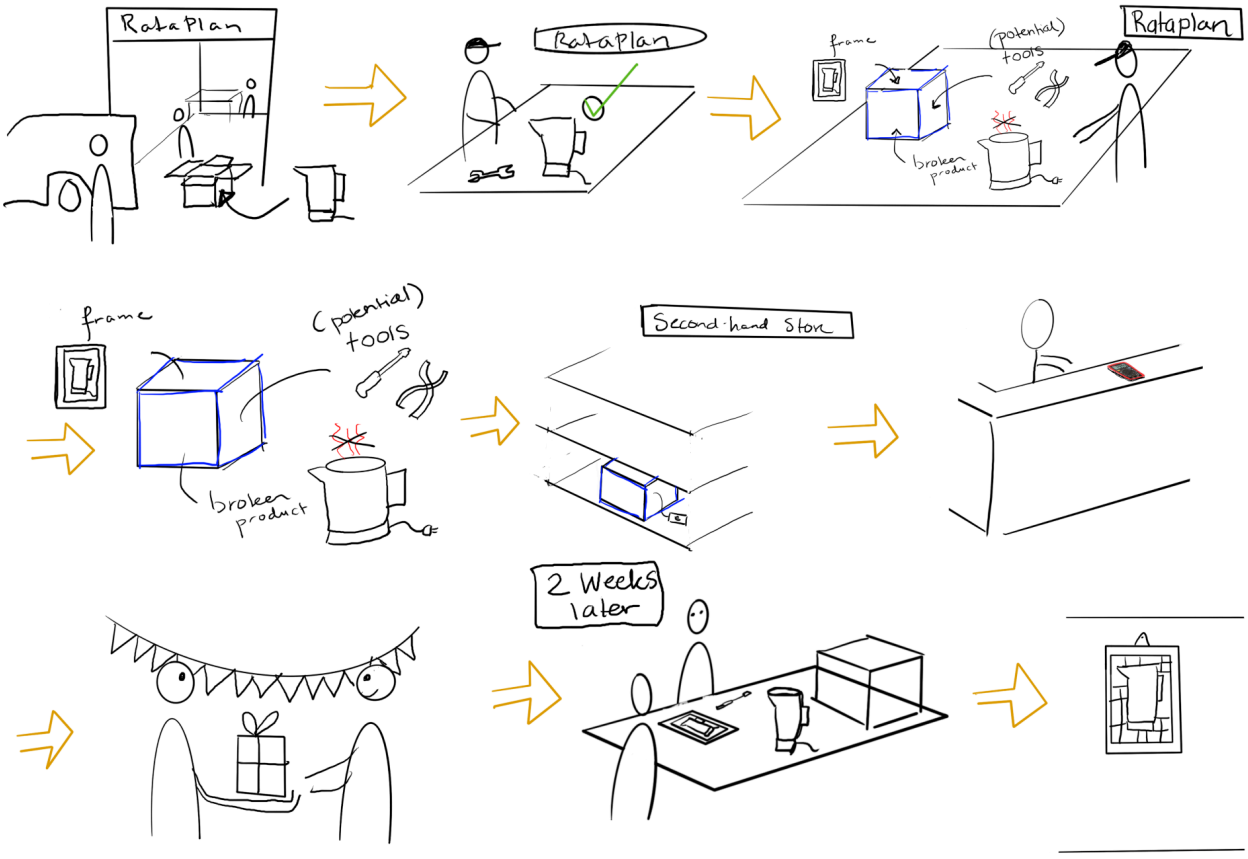

Figure 33: Puzzled: storyboard

9.1 Physical elements

In this subchapter, all the physical elements of the product will be discussed and further analysed. In this package there are several elements: the tools, the broken product and the frame/manual (see Figure 34).

9.1.1 Tools and spare part

Firstly there will be tools. This array of tools is needed because for any one product there are different tools needed to enable repair. Different 'repair essentials' will be provided in the package depending what is critical to facilitate repair. For example if a multimeter is necessary for repair this will be included in the package. This will be the same for pliers, a soldering iron and a screwdriver set.

These tools will always be acquired for every product and put in with every box. This means the convenience of the consumer is as high as possible.

9.1.2 Broken product

Secondly, there is the broken product. This broken product is broken, but mendable. This is verified by an employee from the second-hand store and if it is deemed mendable it can proceed. In this sense there is a high guarantee of the product actually being repairable. It will save the employee a lot of time, since he/she does not have to repair it himself. More will be elaborated on this during Chapter 9.3.1.

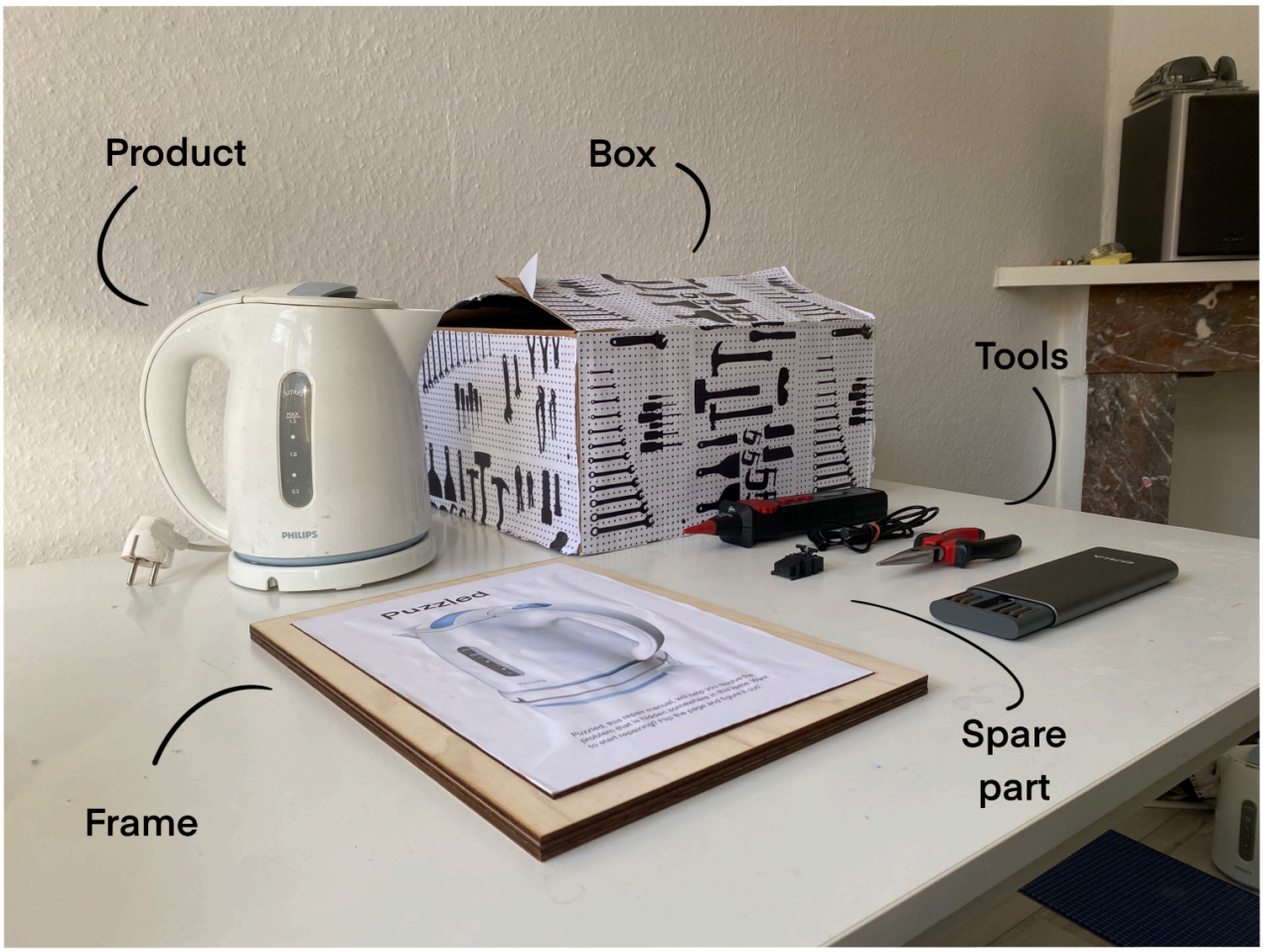

Figure 34: Physical elements of the design:

9.1.3 Box

The box itself is also a big part of Puzzled because it should be something you would want to gift to someone. The cover could be something like showed in Figure 35, with a feel of DIY but with hints of technical specifications. When you buy Puzzled, like I stated before, everything is already in the box when you acquire it.

Figure 35: An example of the cover of the package made with ChatGPT

9.1.4 Spare part

If the fault is known, and this is due to a faulty part, a spare part can be put into the box as well. This saves the consumers time and makes for a more fun experience, since they can repair the appliance in one sitting. It also links back to demand number six in the list of wishes and requirements: ''keep the amount of time, passive or active, as low as possible''.

9.1.5 Frame

At last, the frame. The frame consists of a manual and a picture in a frame that you can remember the night by. What this consists of will be elaborated on in Chapter 9.2.

9.2 The frame

The frame consists of four sides. In the next paragraphs, all these sides will be outlined. In the actual design, you flip each part to go to the next.

Cover (1)

The first layer is actually the cover. It is just a big picture of the product that the person bought, with a small introduction of what Puzzled entails.

Puzzled

Puzzled, this repair manual, will help you resolve the problem that is hidden somewhere in this kettle. Want to start repairing? Flip the page and figure it out!

Figure 36: Side one, cover

Diagnosis (2)

The second side is the exploded view of the same product. It gives a full breakdown of all the parts of the product, where they are in the product, and their name. This product is divided up into three parts: green, blue and red (see Figure 37). Green is the part of the product where you switch the kettle on if he/she wants it to work. This is also the part that always stays plugged in in a normal situation. Blue and red together form the part that is detachable from the plug normally but these have been divided up to ease distinguishing between the parts. In the red sequence, you enter into the top part of the kettle. In the blue sequence, you enter via the bottom. In both red and blue, you have to pass part BT1, which stands for Bottom Top 1.

Furthermore, it also gives some key reasons as to why this product is broken. If you follow each color you arrive at several options, from most to least likely and if you flip the part, as shown in Figure 38A and 38B, you can see how to get to this potentially faulty part.

Diagnosis page

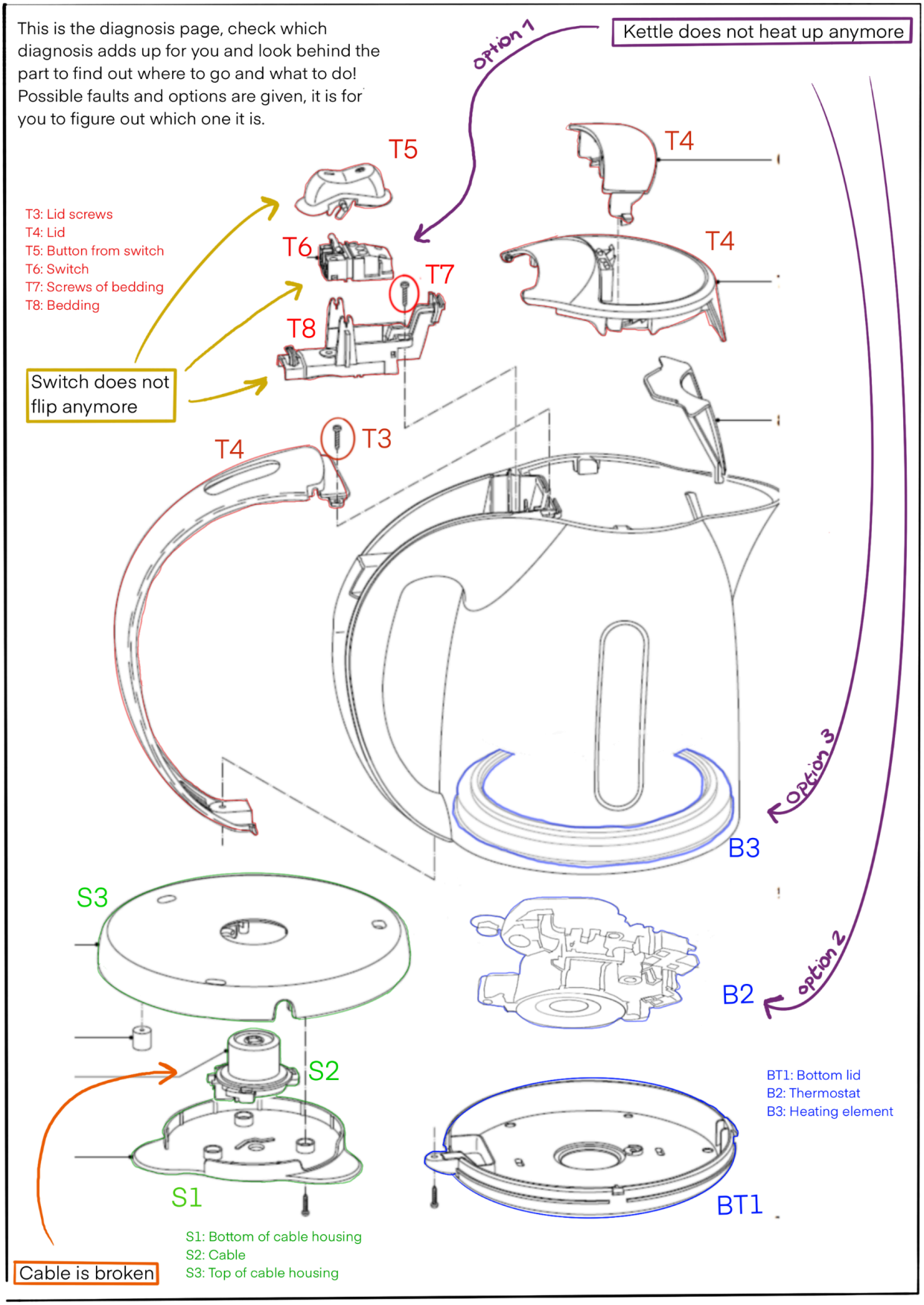

Figure 37: Side two, diagnosis

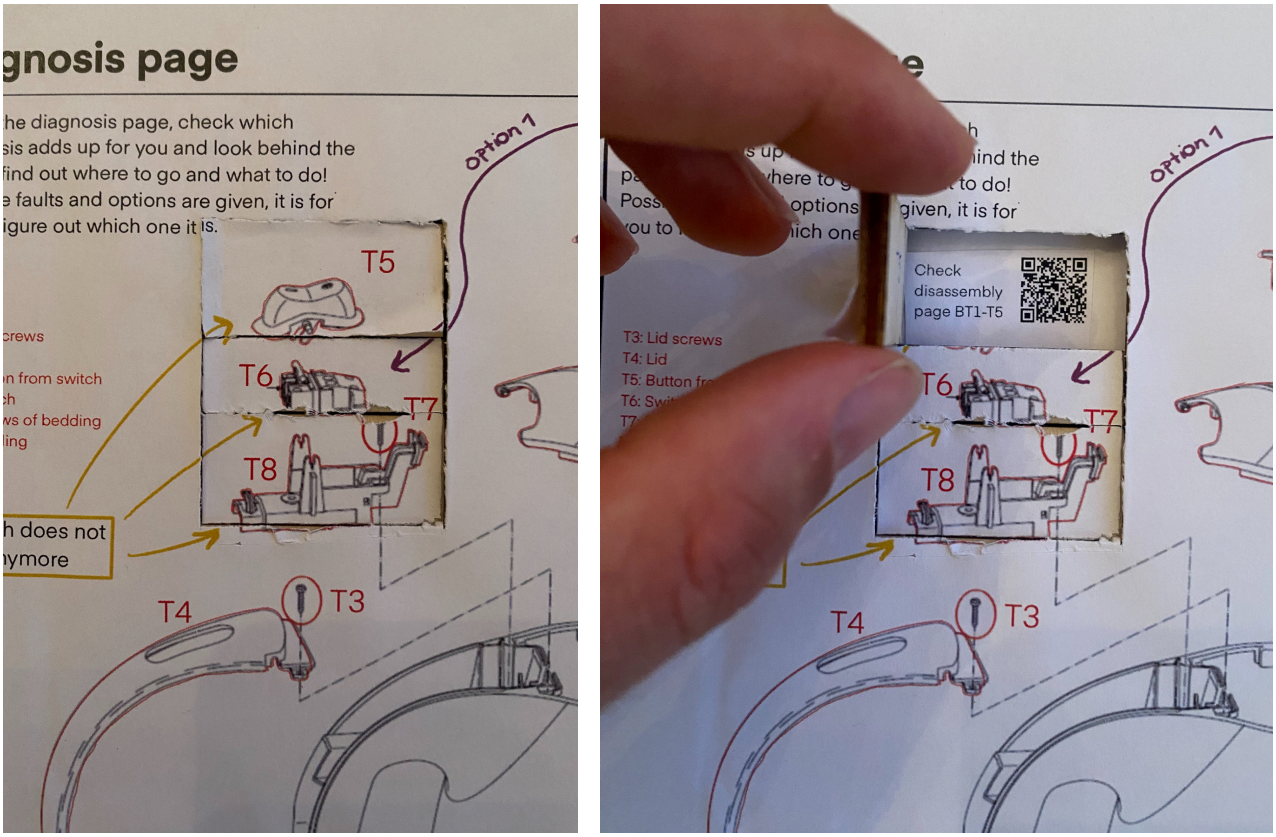

Figure 38A and 38B: Flipping the layer underneath the part.

Test and repair page (3)

This page is basically the same as the diagnosis page, although it has a different purpose. In this page there are videos on how to test and replace certain parts. If you look at the part on the exploded view, it guides you via the arrows to the video you need.

Test and repair page

This is the test and replace page. From the diagnosis page you gathered wat a faulty component might be. Here you will first figure out if it is actually a faulty component by testing it, if that is the case you can replace it with the spare part that is in the box.

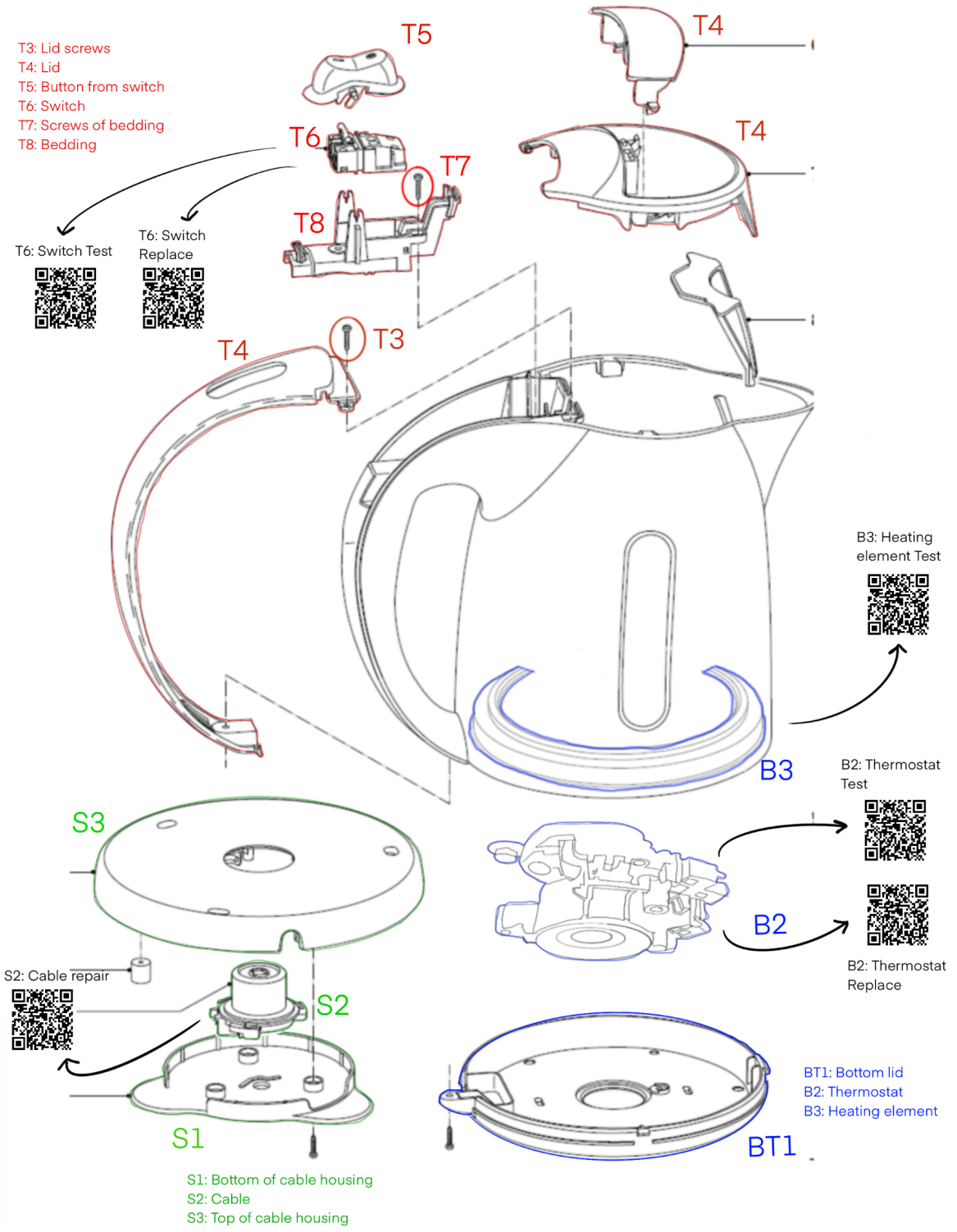

Figure 39: Side 3, test and repair

Frame (4)

This is the side that someone can use after repairing and hang as a memory on the wall (Figure 40). It is a page that can be used for a personal message that someone can type before coming to the store. This is a short, personal message and a nice picture of something they did together. This can be designed on the puzzled site, they print this message on the backside of the frame.

Hi Steve,

I hope you will keep your kettle forever, although I think you can, since you already have the tools and the manual for it. Hit me up for a cup of tea once in a while please. Congrats again! With this you can always remember our ski holiday last year!

Chris

Figure 40: Side 4, frame

9.3 Puzzled: Feasibility

In this subchapter, the feasibility of the design will be discussed. This will include why it came to be, the financial aspect and what the potential company, BKN, which is a overarching organisation of second-hand shops, has to do in order to make this work.

9.3.1 Why Puzzled?

Puzzled focuses on the fact there are a lot of devices being donated to second-hand shops and that these shops do not have the capacity to repair all these devices. Looking at the BKN-monitor of 2022 and 2023, which is the monitor for all the second-hand shops in the Netherlands, this shows that the amount of electric devices* donated to second-hand shops increased from 13 percent out of 144 million kg to 19 percent out of 194 million (Beumer et al., 2023) (Schootstra et al., 2023). This is an increase of 96% in one year. A lot more devices are being donated, almost double in a difference of one year. Capacity-wise, a lot of pressure will be on the employees, since almost half of them are volunteers, people with a distance to the labour market and people that are there as a hobby, as shown in Figure 41 (Schootstra et al., 2023).

Furthermore, the amount of revenue from these stayed at 9% but went from 125,4 million euros to 188. This is an increase of 42%, which is not half as much as the increase of donated devices. Lastly, the wages increased due to the 10% increase of minimum wage in 2023, as shown in Figure 42 (Schootstra et al., 2023). Less work for the employees would be positive, since that will help in increasing the revenue, since the wages press more on the costs now than ever before. The increasing donated devices, the not so increased revenue gained from electronic devices and the increasing costs of wages make the case for introducing Puzzled.

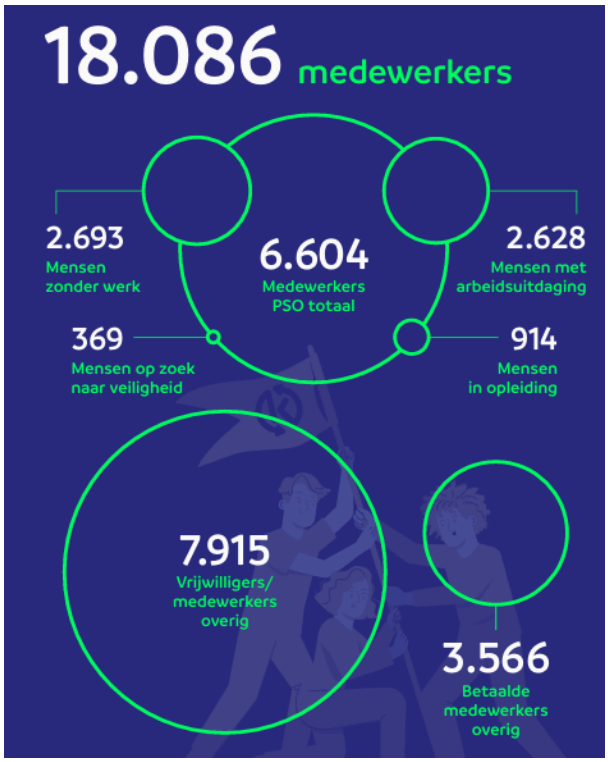

Figure 41: Types of employees of second-hand stores in the Netherlands (Schootstra et al., 2023)

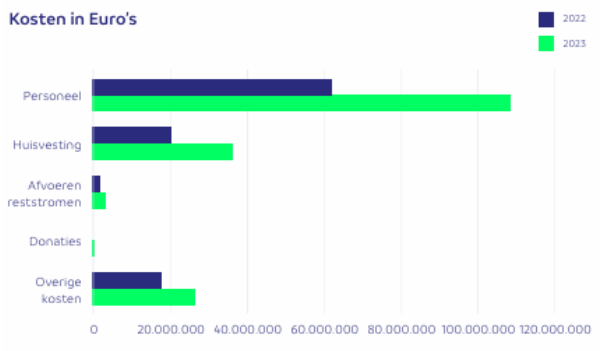

Figure 42: Wages, cost in euros

*This is for all electronic devices, not just small household appliances

With this concept, they only have to check to see if the product is in fact repairable, and then make a box with the necessary ingredients (as stated in 9.1). This will make their output a lot bigger and can give them the ability to sell more second-hand products.

Although this sounds like not too much work, it actually can be. If they take on every device, they need to make manuals for every appliance, check it, make sure it is repairable and change the procedure for every device. This would just be highly ineffective. To make this intervention viable, it is necessary that there would be rather one specific product with the same brand and model that frequently gets brought into one of the roughly 250 stores in the Netherlands a lot (Onze Leden - Brancheverenigingen Kringloop Nederland, z.d.). This would mean a more standardised procedure and can be more easily scaled up, as shown in Figure 43.

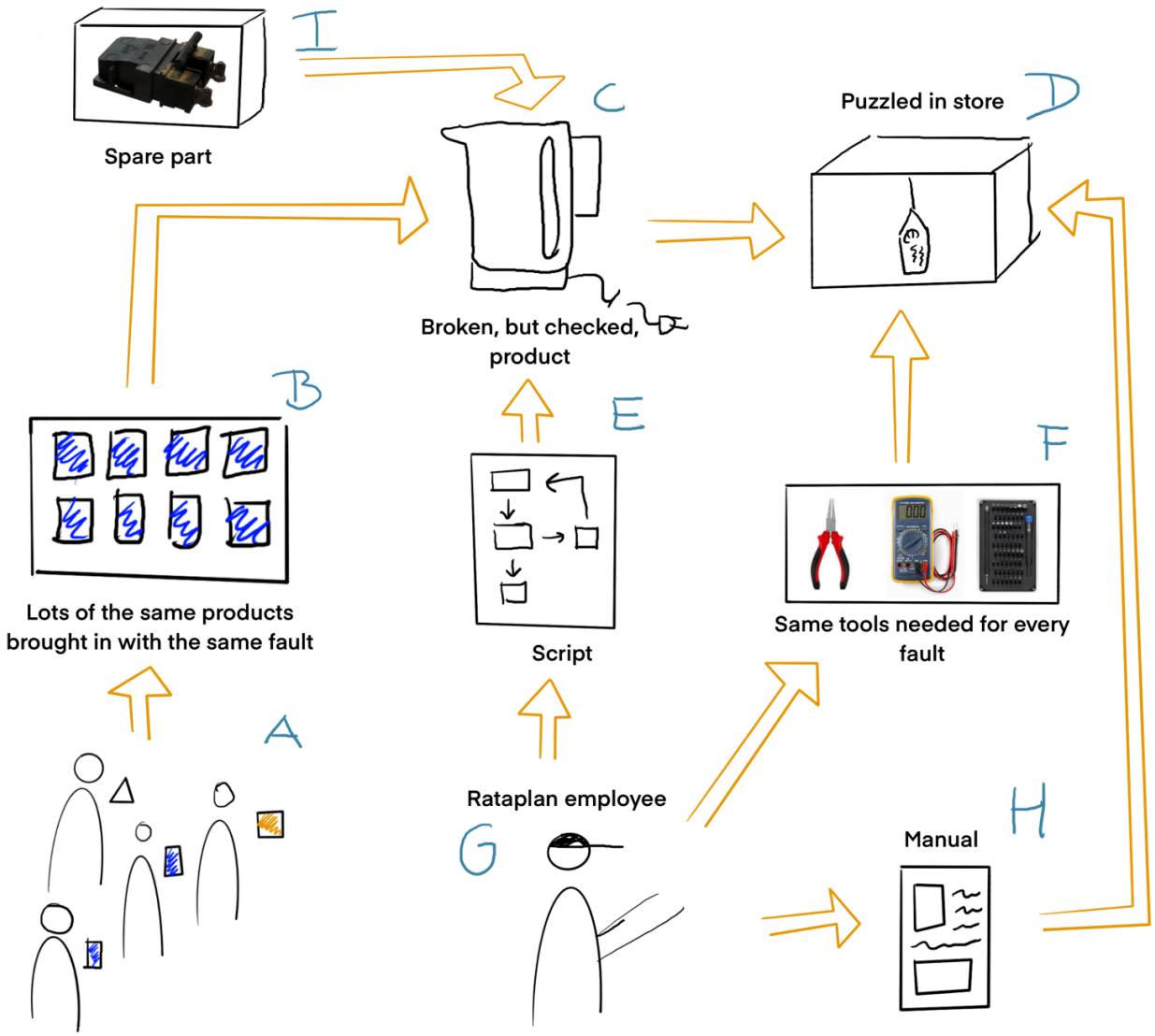

Figure 43: Logistical model, Rataplan

The parts of this storyboard that are important if this concept will fail or succeed is the one where the products get brought in (A) and the one where it is checked (C). How much impact can be made depends heavily on how many products with this same fault will be brought into a second-hand store. The more, the better. Since one manual needs to be made for one specific product, if more sales can be done, this will give more impact to the concept.

If we dive deeper into how this product is checked, some sort of manual needs to be made for checking the product as well. For the Rataplan employee checking the appliances, there needs to be a guide to easily figure out what's wrong. For the Philips HD4646, an employee could for example always check if the switch is still working very easily. If this does not flip as it should, or is very difficult to flip, they would know that that could be a potential problem. A script for how this could work is shown in Figure 44. This script starts with the most potentially breakable part of the kettle and increases from a little of work to check to a lot. This will help with keeping the time needed for repair as low as possible for the Rataplan employees. More insights are in Appendix I.

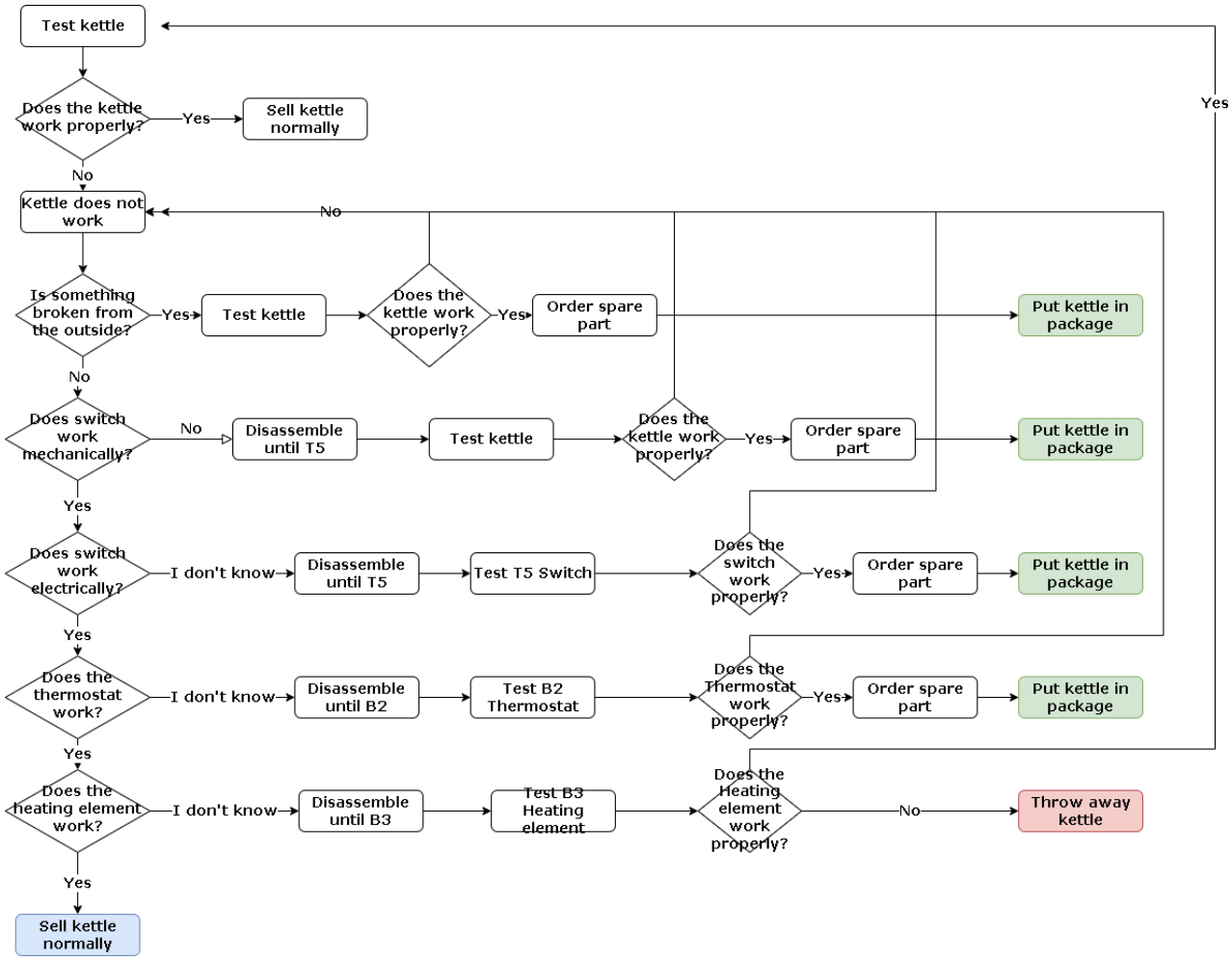

Figure 44: Script for rchecking the Philips HD4646 kettle.

9.3.2 Financial perspective

There are a lot of things to consider before this product can be brought to the market. One big factor of this is the cost. What does it cost to make and how many do you need to sell to break even or make it profitable? The product itself is not put into the cost estimation, since people bring those to Rataplan for free.

We can divide the costs into the developing price for a product batch, this includes the manual (A1) and the script (A2). For the development of this product, that would come out at roughly 16 hours. This is based on the development of making the diagnosis page (3 hours), the videos for disassembly, test and replace (3 hours). Furthermore, figuring out how to repair it in the best way (3 hours), putting everything together (3 hours) and to check how employees can best go about checking the product when it comes in (4 hours), see Figure 45. Having a template for the flow, how things are built-up and how a consumer is talked through the pages will help a lot in speeding up this development.

Type of cost	Hours	Price per hour	Price
A1	12	18,98	227,76
A2	4	18,98	75,92
		Developing price	**303,68**

Figure 45: Developing price based on minimum wage

Adding this up makes it 303,68 euros (Figure 45), because it is not realistic to let a volunteer develop this manual, since these employees have very flexible work hours and might be physically or mentally disabled. This is why this rate is not included. The price per hour is based on the minimum wage for employees in the Netherlands. The wage an employee gets is not what the employer pays him/her. This number is normally increased by 30-40%, based on the rate for employers insurance, their pension, their work expense regulation and the WW- premium differentiation (Ministerie van Financiën, 2025). All these things depend on the individual, where they work and what kind of contract they have. For this calculation, we will use a percentage of 35% over the minimum wage of 2025, which is 14,06 euros (Ministerie van Algemene Zaken, 2025). The wage would then be 14,06*1,35 which makes it 18,98 euros per hour. For volunteers, employers do not have to pay more than the actual volunteer rate, which for Rataplan is 1,40 euros per hour (Rataplan, z.d.).

The second line of costs is the costs that go into the preparation of a single Puzzled product. This includes the checking of the product (B1) and the elements that need to go into the box (B2). Moreover, there is also the box itself (B3), the material on which Puzzled gets printed (B4), cutting the wooden material (B5), the tools (B6) and in some cases a spare part (B7). Appendix J shows how we get to the price of wood per product. B6 and B7 will not be taken into account, since that can depend on what lies in the store, which tools are necessary for which fault and what people might have laying at home. This either comes out as 3,16 euros (Figure 46) or 11,95 euros (Figure 47), depending on who does that.

Type of cost	Hours	Price per hour	Price
B1	0,25	1,4	0,35
B2	0,25	1,4	0,35
B3			1
B4			1,21
B5			0,25
		Product preparation	**3,16**

Figure 46: Product preparation price of a volunteer

Type of cost	Hours	Price per hour	Price
B1	0,25	18,98	4,745
B2	0,25	18,98	4,745
B3			1
B4			1,21
B5			0,25
		Product preparation	**11,95**

Figure 47: Product preparation price of a minimal-wage employee

Before we can think of bringing a concept forward, it is wise to think about the price of the product. What would people spend on a gift for a good friend? Concluding from a report of 2000 Dutch people, the maximum spending amount on a birthday gift is 25 euros (Hoeveel Geef Je Uit Aan een Verjaardagscadeau?, z.d.).

So if we take into account all the tools that need to be bought and we put these into the price of the whole package, we know the revenue that will be made for one product and the sources that were used to make up the tool price. I also mentioned that people can get the product delivered at home, however, they pay for this additional cost. It directly takes away from the revenue that Rataplan can make from this product. This is why it is really important to have good deals with certain manufacturers that give discounts when buying in bulk.

Figure 48 is the revenue without bulk per product and Figure 49 is the revenue with buying in bulk. Only with the multimeter there was no option buying in bulk. Per product made, this can save over 50 cents. Moreover, checking the internet for good deals can also make a huge difference, only one deal for a multimeter can save a difference of almost 2,50 euros of revenue per product sold, which is relative to the last revenue after tools displayed before. The tool sources are displayed in Figure 50.

Spending amount	25
B6 Multimeter	6,87
B6 Pliers	3,49
B6 Screwdriver	1,69
Revenue after tools	**12,95**

Figure 48: Tool price without bulk discount

Spending amount	25
B6 Multimeter	6,87
B6 Pliers	3,07
B6 Screwdriver	1,49
Revenue after tools	**13,57**

Figure 49: Tool price with bulk discount

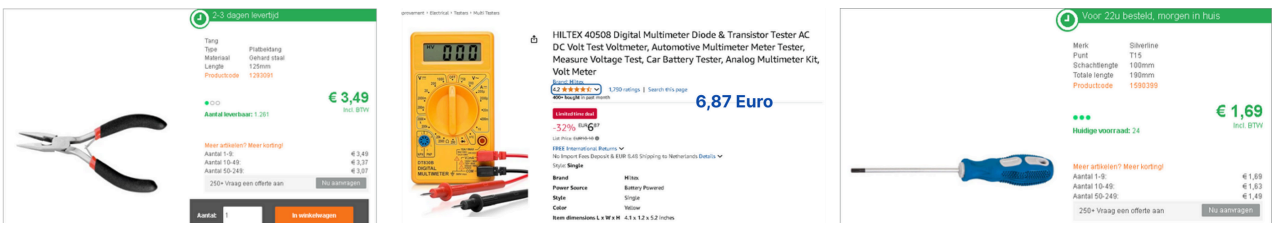

Figure 50: Tool sources on the internet

Having looked at the total revenue, that comes out at 13,57 Euro revenue, which I don't know is enough to actually make a profit. Moreover, it is also not definitive if this profit is more than what they would get for selling a fully functioning kettle. Making the profit higher could be done by selecting products that have a higher value, such as a vacuum cleaner or blender. Although it should be noted that it would cost more time to develop since these products are more complex than a kettle and thus have more diagnosis options, more parts that are prone to failure and a script that will be more complex for employees to use. This could include more expensive tools as well. Therefore, the gift price also would go up drastically. Another option would be to select tools that do not require as much of an investment to buy.

The pilot batch of this product is 50, since that would mean, if BKN launched it nationwide, one shop needs to get around ½ of the same product being donated to them in a week or two week's time. Doing this for over a longer time, they would need 10-20 weeks to reach a product count of 250 models. The most realistic scenario to me would be that the development will be done by an actual employee that might even be getting paid above minimum wage and the preparation will be done by a volunteer. This scenario is stated under here. Why I chose this scenario and why BKN will do as well is because the product preparation price done by an employee being payed minimum wage is almost four times as much and therefore not feasible. I will show both the revenue of 50 and 250 products with the product preparation price of an employee being payed minimum wage in Figure 51. As you can see, after 50 products, there is a big loss, and after 250 products, the gain is 22 times lower than with the product preparation price of a volunteer Figure 52.

B	Amount of products sold	Revenue after tools	Total sales price	Developing price	Product preparation price	Total preparation price	**Total Revenue**
	50	13,57	678,5	303,68	11,95	597,5	-222,68

Figure 51: 50 products sold with preparation price of a minimim wage-employee

B	Amount of products sold	Revenue after tools	Total sales price	Developing price	Product preparation price	Total preparation price	**Total Revenue**
	250	13,57	3392,5	303,68	11,95	2987,5	101,32

Figure 52: 250 products sold with preparation price of a minimim wage-employee

D	Amount of products sold	Revenue after tools	Total sales price	Developing price	Product preparation price	Total preparation price	**Total Revenue**
	50	13,57	678,5	303,68	3,16	158	216,82

Figure 53: 50 products sold with preparation price of a volunteer

This is different with the other scenario, shown in Figure 54 with 250 units sold. With 50 products, there is a small gain (Figure 53), but if this is increased, it can be seen that the developing price stays the same while the product preparation price weighs more heavily on the costs (Figure 54).

There are still lots of questions about implementing this design from a financial perspective, but the revenue does get more positive with a higher sales volume. Furthermore, selecting tools that cost less to invest in, choosing a product with a bit more value, streamlining both the development and preparation process could have a big factor in whether or not Puzzled is feasible in the real world.

D	Amount of products sold	Revenue after tools	Total sales price	Developing	Product preparation price	Total preparation price	**Total Revenue**
	250	13,57	3392,5	303,68	3,16	790	2298,82

Figure 54: 250 products sold with preparation price of a volunteer

10 Validation of final design

To validate the final design, a test must be done to see if the final design adheres to the requirements and wishes drawn up in Chapter 7.2. For this test, a test plan has to be made. Every participant has to diagnose a fault in the Philips HD4646 kettle and repair this fault. There were two user tests, one for Puzzled V1 and one for Puzzled V2. The user test for Puzzled V1, for which the prototype is explained in Appendix K, consisted of two participants, both male, one of 26 years and one of 27 years. The results of this test are in Appendix L.

The test of Puzzled V2, for which the prototype is explained in Appendix M, was done with two participants per test. Each group consisted of one male and one female with the first group both aged 24 and the second both aged 26. The first couple were both students with higher education and the second couple were both just starting jobs, also with a higher education. The results of this test are in Appendix N. This last one is the test I will use for the final validation. On reflection of the outcome of this test and the feasibility of the design (Chapter 9.3), Puzzled V3 was created, which is explained earlier in Chapter 9.1.

10.1 Set-up

In this test, participants have to find the faulty switch (T5) as shown in Figure 55, replace this switch with a new one and test it. Only this test will be done because there is not a big enough sample size to put another variable in. This would only make the test less reliable. The switch was chosen because it is an electrical component, which consumers are not very acquainted with, as stated in Chapter 4, so is not something they would be familiar with fixing. Additionally, all three components have the same method of replacing with only pliers needed. Therefore, it is the same difficulty of repairing. The switch has the longest and most difficult disassembly sequence of the three electrical parts. This makes it the most interesting part for the test.

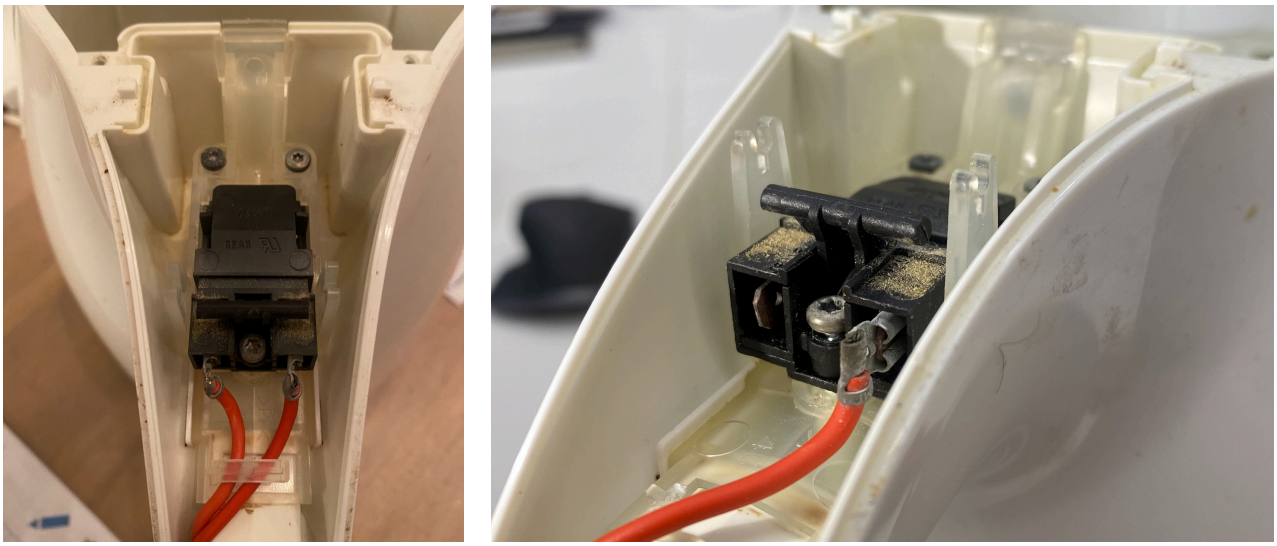

Figure 55A and 55B: T5, switch

The participants first have to go through the disassembly sequence from BT1 to T5 (Figure 56), before replacing the switch and finally testing the replaced switch. These are the only test and replace parts that are fully worked-out. During the validation, what comes out of this test set-up will be validated. The test will be started with this set-up in mind (Figure 57).

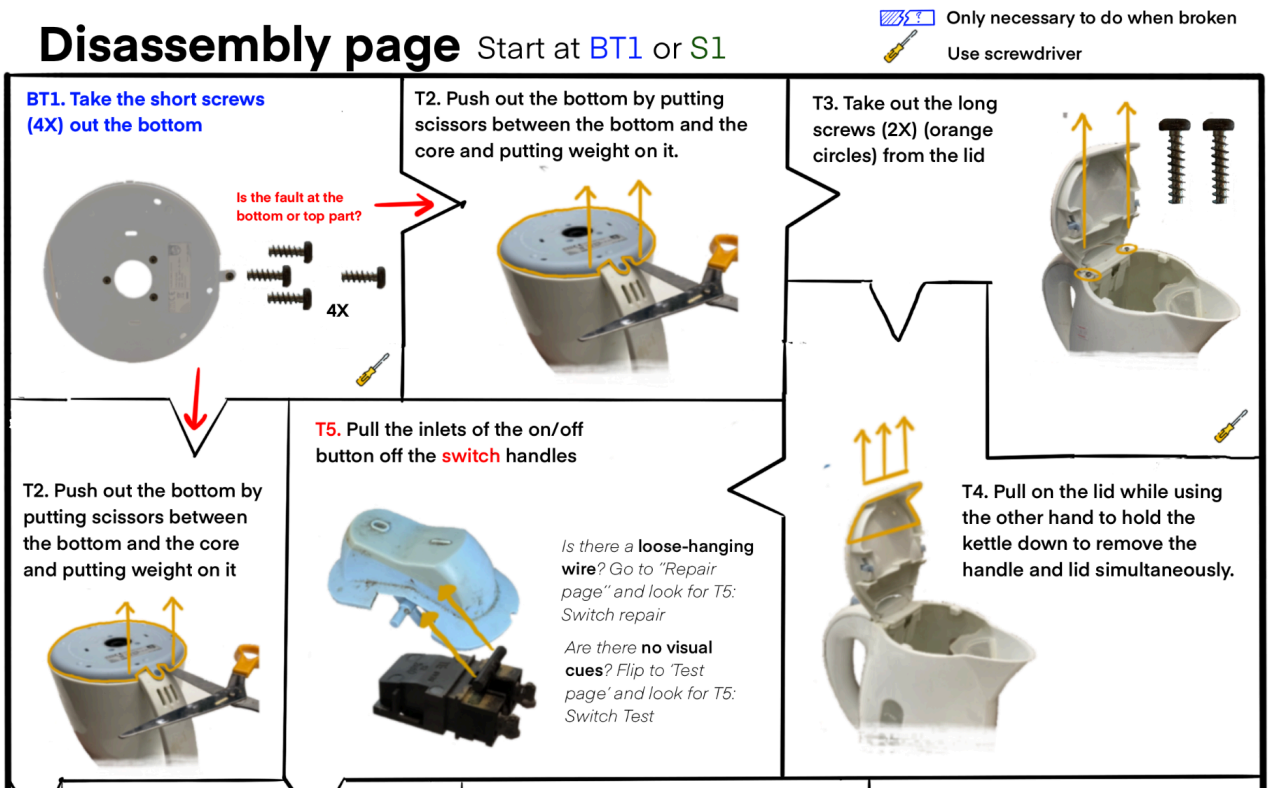

Figure 56: Disassembly sequence from BT1-T5

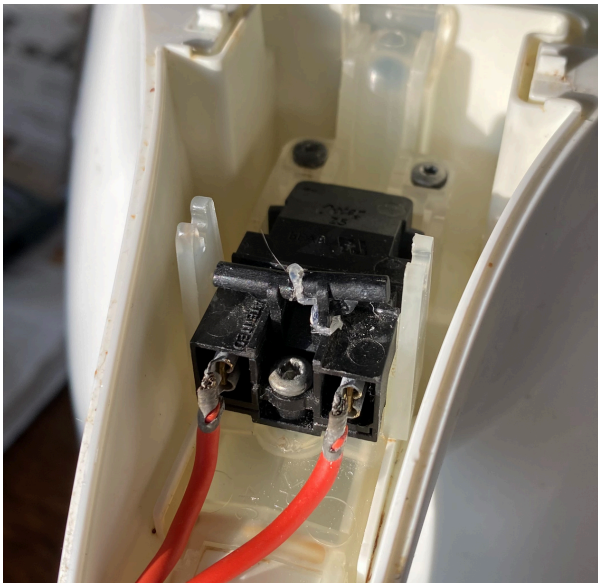

Figure 57A and 57B: Set-up of the test

There were no technical issues experienced during the test, since the technical part of the design was very well thought-out. Users however did struggle with the flow of the design, which was taken into account during the design of Puzzled V3. Working in collaboration went well, but could also have been based on the fact that the participants were both couples. One important thing to note is that during the second test, the spare part needed in the repair, in this case the switch, was put in the box with the other components required for the repair. This hinted to one participant that this would be part of the solution. This was a bit of a shame, as it revealed a large part of the mystery of the repair puzzle. A double bottom should be invented for the box, so that the spare part, if it's necessary, is not immediately seen as a clue for the answer.

The test did not include how participants would go to the store and actually select Puzzled themselves, this is taken into account by some questions from the questionnaire. In the test, a movie was included showing the testing of the switch as well as a booklet. Participants mentioned they would rather see a small video than the booklet since there is more intonation, more of a personal feel and more room for background information. This also helped shape the choice for Puzzled V3. What has changed between Puzzled V1 and V2 going to V3 can be seen in Appendix K and M.

Figure 58: Test 1

10.2 Validating requirements

After the test, the participants were asked to fill in a questionnaire about the design (Appendix L) to validate the design. I based the questionnaire on the requirements I set, to directly validate if my design fulfills the purposes from the requirements of Chapter 7.3. The interesting results from the questionnaire can be found in full in Appendix N. In the next paragraph, only the most important requirements will be laid out and an assessment will be made on whether the design reached them.

The first requirement that needs to be answered is: Does the design increase motivation of the consumer to start repairing (1)? This is not only dependent on the design itself, but also if you want to buy it in the first place. In the test, I put the design immediately in front of the participant, without them having to go to a second-hand store and actually buy the product. In this smaller sense of motivation, they did find the design itself motivating enough to start repairing, since all of them said that it motivated them to start the repair. This was mostly said since they liked how the diagnosis page showed them what the options could be, and where to start to look.

However, when I asked them if they would buy this from a second hand store, three out of four said no. This was due to various reasons including the fact that they did not know whether someone they knew needed the product, they already have the same product that works, they rarely visit second-hand stores and the friend they want to gift the product to, already likes to repair. One participant commented that it would be a very fun gift to give to someone.
In this sense, you can see that there are still a lot of uncertainties in whether the trigger is strong enough, although this also has a lot to do with the in-store-price, as stated in

Chapter 10.4.

The second question that is important to answer is: Does the design provide consumers with a strong strategy for fault diagnosis and the right information needed for repair (2A & 2B)? The design does provide a strategy and visual cues for fault diagnosis. The diagnosis page gives participants the possible reason why the product is faulty and the disassembly page gives information on where the component is located. This was clear to all the participants who had no issues with this. Furthermore it also helps you to confirm what the faulty component could be, even if there are no visual cues.

Tools are provided with the design, and so is how to use these tools, see Appendix N. However, the estimation of costs, time and tools are not really necessary for this design and the environment in which this design lies. It is an all in one gift, so people using this design will not worry how long it takes, since they do it out of pleasure or curiosity to start designing, and less from a perspective of frustration.
The tools are given during the repair, so this aspect is fulfilled. As for the positive emotions, people did feel them, although one participant was confused at the start, all of them felt like it was a sort of puzzle in the end, and once they started they went along for the ride.

The last factor that was not in the list of requirements but is interesting for the potential wider impact of this design is whether people would get inspired to do more repairs in the future. Three out of four participants said yes indicating that, after repairing the broken kettle themselves, they realised it is easier than they originally expected. Furthermore, they learnt how to use tools they have never used befores. It was important to not only let the participants do a certain series of actions, but also explain why it was necessary. This is what the videos could help with in Puzzled V3. After the repair, because they now have the tools and expertise to go with it, it will be easier for them to do repairs in the future. Both of these things will provide them with the technical knowledge to have a better grip on future repairs.

Out of all this information and feedback I received, a final prototype was made. This was based more on videos that look at both how something is repaired, why it is done that way and what that is based on. Additionally it has a flow that is easier to understand and follow for the consumer.

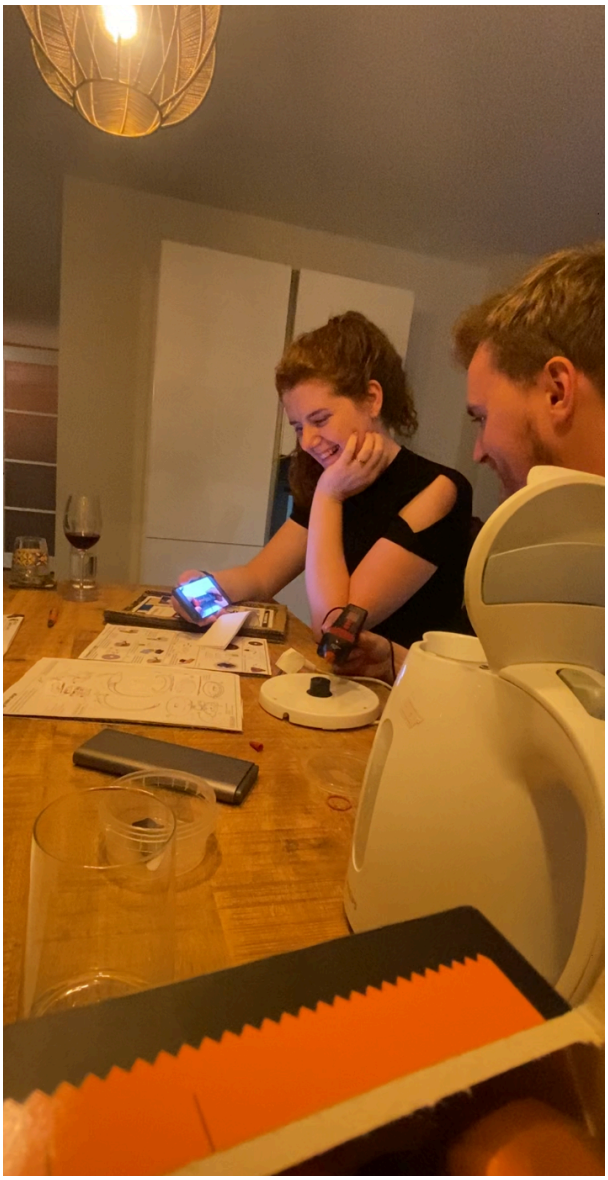

Figure 59: Test 2

10.3 Conclusion

Based on the validations of the test in Chapter 11.2, we must assess whether it answers the design goal and the overarching goal: reducing environmental impact in the electronic appliance sector. The research conducted during this thesis showed that increasing a consumer's ability to repair small household appliances themselves was the most promising strategy to reach this goal.
The design contributes to this behaviour change by increasing the motivation of consumers to start repairing. The design itself helps consumers to figure out what is wrong with the product, provides the necessary tools for repair and includes the relevant information on how to execute the repair. It helps inspire and facilitate people to execute more repairs in the future, as they acquire skills, knowledge and equipment during the repair of the Puzzled product.
There are two important factors that need to be considered that may limit the scope of this research. Firstly it is acknowledged that the design was not tested with enough participants to get a more reliable data set that can represent consumer opinion. Secondly, the design was not tested in an actual second-hand store so the likelihood of consumers frequently purchasing the product is unknown. The small sample of participants indicated they would not be overly eager to buy this product if it would be for sale in a second hand store. If this product were to develop further both of these factors should be explored.
To summarise, all the product-based design factors have been achieved, including diagnosis, information, provision of tools, working with tools and the motivation to start repair if it is put in front of you. For BKN to take the next steps to launch this new design there is still a lot of work to do regarding impact, viability of the design and purchasing behaviour of consumers . Only then could factors such as selecting the right product, making the manual, selecting the appropriate tools and checking product faults be considered before the product could be released in their store.

10.4 Recommendations

In this subchapter, I will assess how this research can be followed up, how it could be improved in terms of the technical specifications and readability of the manual and frame, and what would be needed to bring it to the market . As stated in the conclusion, there is still a lot of work to be done regarding viability and feasibility. In particular more assessment is needed regarding the financial profit of implementing this design at any second-hand store. Additionally, more knowledge is needed on whether consumers will actually buy this product from the store. This chapter will be divided into recommendations about the product based side but also about the product-environment based side.

10.4.2 Product-environment-based recommendations

Making the manual universal

Due to the large range of designs for any one item the specificity of Puzzled 3 means it could only be used for a small number of models limiting the profitability for Rataplan.
To make this product more effective, there could be a manual made that is not specific for one product, but for multiple or all products of one product type. After speaking to Rieneke Post of Repair Cafe (Appendix O), this would be possible for smaller & cheaper product types , such as kettles and filter coffee machines. For more expensive products, such as vacuum cleaners or fully automatic coffee machines, as these are more complex and expensive, product-specific manuals are needed. Therefore, Puzzled should be aimed at these smaller appliances first.

Selecting the product

For the second-hand store it is important to know which product could be used for their next launch. As discussed in Chapter 10, it should be something that is frequently brought in, has specific & common faults, and where a spare part can be easily found for. It should also be a product that people want to purchase. Second-hand stores have data to help prioritise the appropriate products to be selected for this design, since they will know which sort of products come in with which sort of faults.

User testing

As discussed before, whether people want to purchase the design is not evaluated in an actual second-hand store. This needs to be tested before this design can actually be introduced.

10.4.3 Product-based recommendations

Screws

As I found during the first two tests with the first prototype (Figure 60), it was obvious a place was needed for participants to safely store their screws to avoid them getting lost, halting the repair and potentially demotivating participants to repair again. Participant 1 put theirs down on a piece of paper, whilst participant two put the screws on the diagnosis page, so he knew where they came from. To manage this I designed a solution involving placing the screws in a corresponding space in the frame. This is done by integrating the part number with the appropriate screw shape on the frame, see Figure 61.

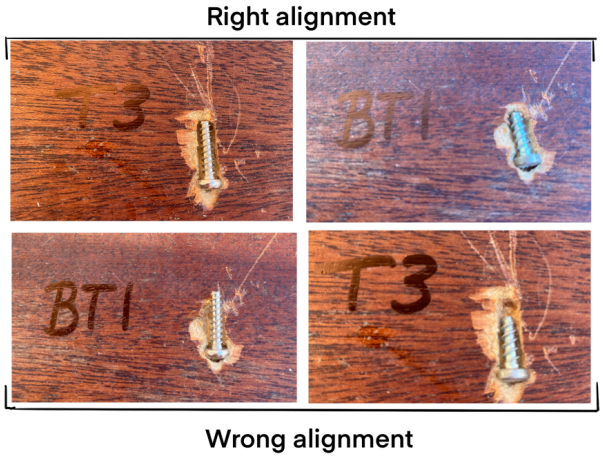

Figure 61: Aligning screw holes on the side of the frame

The correct way is shown on the two top pictures, and the wrong way is shown on the bottom two. It can be seen that the screws will not fit if you put them in the wrong silhouette part. This design ensures the screws aren't lost and adds an additional element of interaction which further enhances the repair experience.

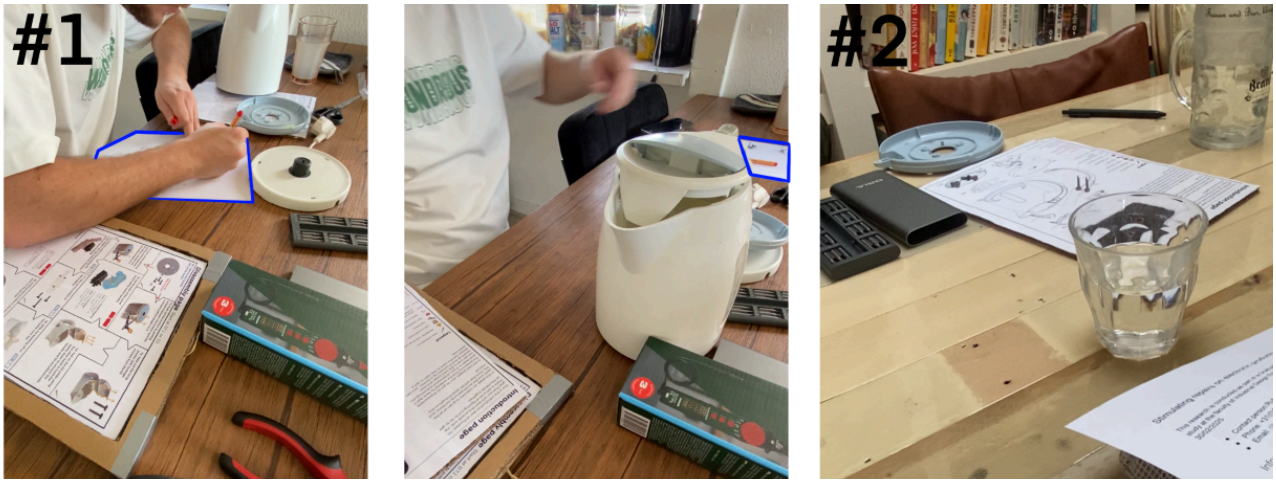

Figure 60: Storing the screws during testing

10.5 Reflection based on the outcome of the design

As discussed in the conclusion, there is still a lot of work to be done regarding the viability and feasibility of the product, the actual income of products into second-hand stores and whether consumers will actually buy this when they come into the store. Viability and feasibility were taken into account too late in the design of this product. On reflection, feasibility + viability go hand in hand with the power of the product you want to launch.
For a long time during this project this was not at the forefront of the design considerations. For me, viability was something to consider after a product design was complete, but in reality the feasibility is ingrained in the heart of the whole product development process, as shown in Figure 62.

The changes from Puzzled V2 to V3 was where I really began to take viability and feasibility into account. The product became leaner, more intuitive for the consumer, and costs and reducing costs were considered. Developing a product is not only rethinking your own product through testing, but also going from part to part within the product and its environment. Once you are happy with one part, you may switch to the other side and then discover new problems to overcome This is essentially how you make progress. I am, however, quite pleased as to how the product worked out and that I made a manual that people can effectively use to repair a kettle without too many problems. This is something I am very positive about.

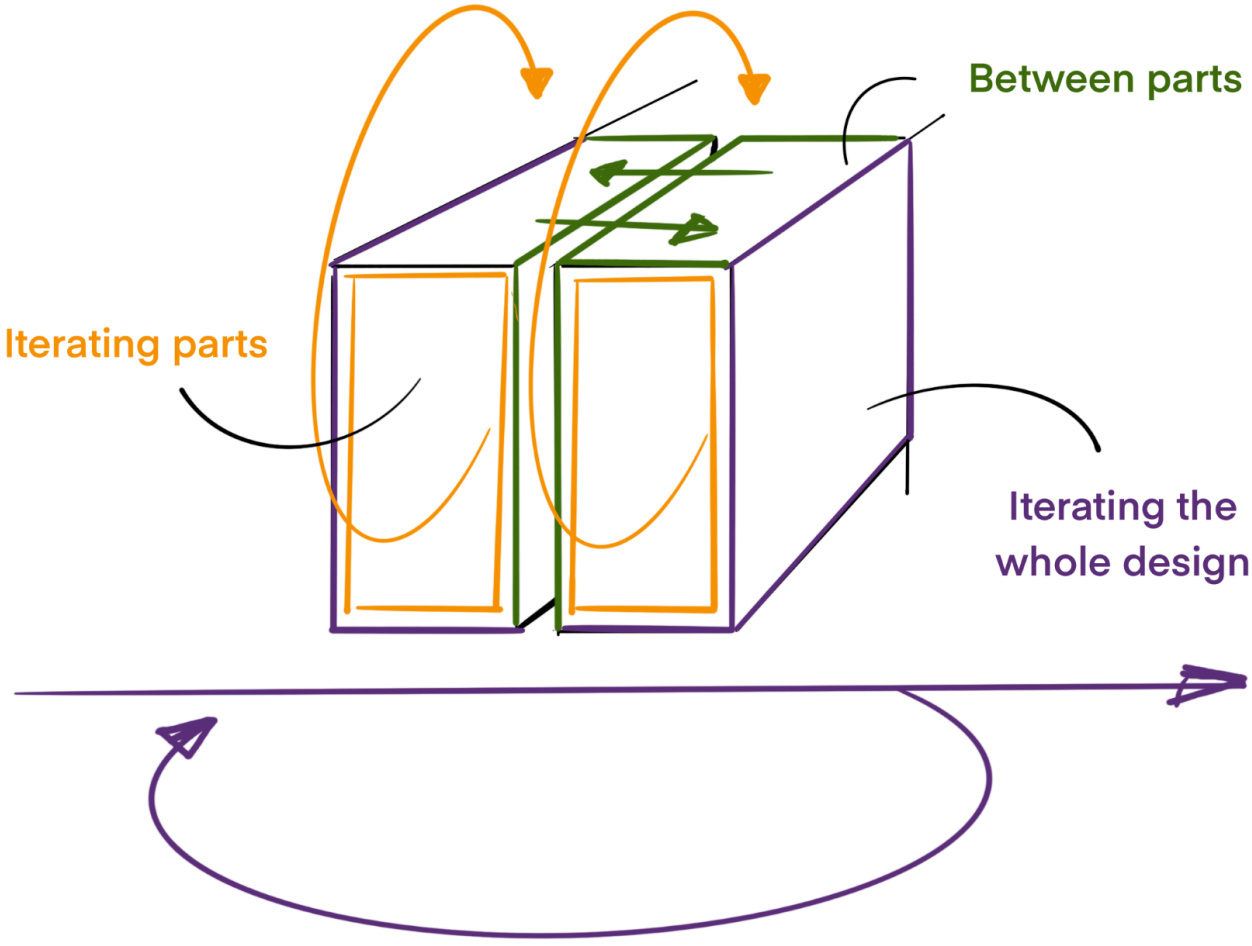

Figure 62: Iterations regarding feasibility and technical specifications during development

11 Reflection

While making this reflection there is one thing I will be, honest. I learned an awful lot, starting from communicating with different stakeholders to knowing that viability and the technical perspective of a design go hand in hand. There were lots of times where the thought '' I'm not feeling it anymore'' raced through my mind along with all the other forms of critique, other small actions that were needed and the slowly impending deadline.

However, during all those times I still thought: ''It is just a report, it's just critique, take it all in and let it go''. ''People are just there to help you, not break you down''. Keeping a positive mindset, good faith and a willingness to admit your mistakes and set aside your pride is what people forget being a good designer is. I might even value the things I learnt from a mental perspective more than the technical and design side of the spectrum, because I didn't expect to learn so much of them.

I learnt a lot about how to communicate with stakeholders and that the real world is very different than I expected. It is much more difficult to launch a project into the real world, because people only have a slim margin of time, their own concerns and can be resistant to change in how their system works.

As designers we must try to find the space and ensure to close all the gaps that your design still has. The viability aspect comes into account here as well. You can have a good thing from a technical perspective, but just as important is the viability of the design. I didn't know this before, but I'd say it is definitely 50/50 in terms of importance. Maybe even 60/40.

Additionally, how you bring over your ideas is crucial through a well-thought-out report. Filling the gaps here is the most easy to do, but can only be done with good analysis, that not only you but the people you work with understand. All these things rely on good time management, which is something that I still have to work on, since this is incredibly hard. Project management and prioritising what to spend time on and when is not my strong suit However through this project I have worked on this and have learnt some useful lessons and skills for the future. Through accepting and learning from my mistakes, using my strong sides and much more I will have a good basis to start my career. This was definitely a good test for that!

The last thing that I want to add is that I absolutely loved repairing a product and helping others figure out how to repair it as well. This gave me so much energy during the project, balancing thinking and doing makes for a perfect study day (Figure 63).

Figure 63: Me figuring out how to test the kettle with a multimeter

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