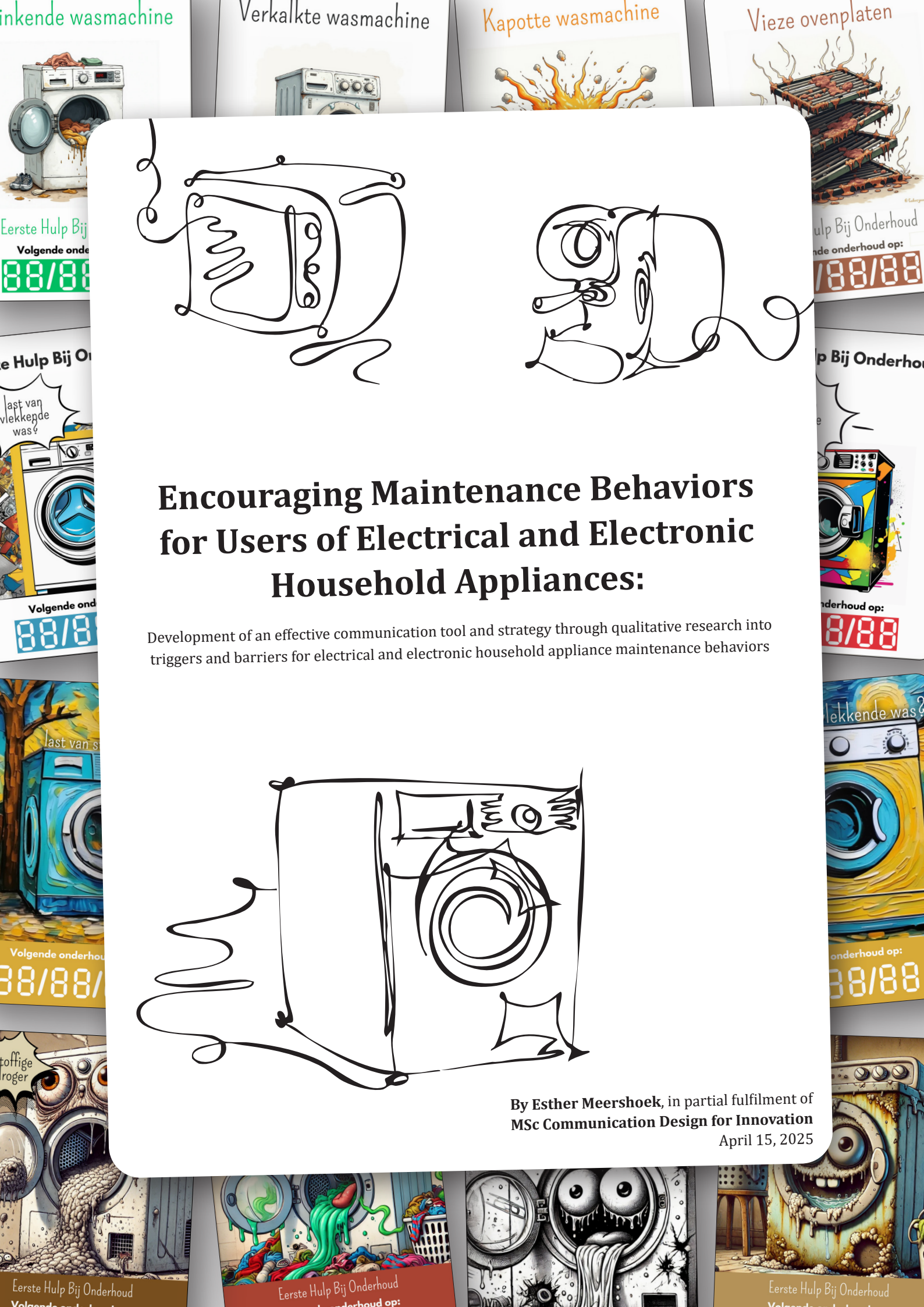


Encouraging Maintenance Behaviors for Users of Electrical and Electronic Household Appliances:

Development of an effective communication tool and strategy through qualitative research into triggers and barriers for electrical and electronic household appliance maintenance behaviors

By Esther Meershoek, in partial fulfilment of
MSc Communication Design for Innovation
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Encouraging Maintenance Behaviors for Users of Electrical and Electronic Household Appliances:

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Preface

This graduation thesis report marks the end of my master's in Communication Design for Innovation, and consequently my student life at the TU Delft. After finishing my bachelor's degree in Industrial Design Engineering, I decided to start a master's degree at a different faculty. I chose CDI, because I appreciated its interdisciplinary approach, focusing on the combination of social sciences and technological development, while still taking a design approach in solving issues.

The beginning of this thesis project started somewhat a year ago, when I first responded to the graduation request from Roos. Ever since, I've started to read, talk and learn more about the subject. Although I admit that appliance maintenance is not seemingly an exciting topic, the more I proceeded in the research, the more I discovered that the challenge that this brings is exactly why encouraging maintenance is important, and for me why it has become all the more interesting.

I want to first give a special thanks to Caroline, my supervisor, who guided me throughout the entire project. I really appreciate all the time she has taken to answer my questions, and even when I didn't know what to ask for, she offered consistent support helping me forward. Her directness about what was important, and her honesty about what wasn't, helped me to stay focused from beginning to end.

I also want to thank Daniëlle and Gert-Jan, who supervised my internship at the Ministry of I&W, for the time they took for our weekly coffee break discussions, the structure that they brought to my research process, and their enthusiasm that inspired me throughout this project.

Moreover, I want to thank Éva and Ruth, for the time they put in giving me feedback, and providing input throughout several occasions.

I want to thank Roos, whose practical perspective and hands-on approach really inspired me to take decisive actions, resulting in the final tool design, and also for allowing me to tag along with the sessions from the LLE coalition. I learned a lot from these experiences, seeing how different stakeholders responded, sometimes with pushback but also with enthusiasm toward my design ideas. These experiences gave me the confidence I needed to reach finish line.

Finally, I want to thank my friends that joined me for study sessions (and mostly the coffee breaks), including Rutger, Pauline and my fellow CDI students that listened to my ideas and helped me making sense of it all.

Throughout this research, I have developed a more meaningful appreciation for the fields of behavioral sciences and intervention design. A year ago, in all doubt and uncertainty about my future, I wouldn't have been able to predict where I am right now, how much I've learnt, and where I want to go from here.

I've learnt that in order to adopt new behaviors, more than just the information at hand is needed. Therefore, I hope that if you read my thesis, you will become more engaged with EEA maintenance and hopefully you'll enjoy it just a bit more than reading an instruction manual.

Esther Meershoek, May 2025

Abbreviations

TU Delft = Delft University of Technology
IDE = Industrial Design Engineering
CDI = Communication Design for Innovation

EU = European Union
EGD = The European Green Deal
NCEAP = New Circular Economy Action Plan
ESPR = Ecodesign for Sustainable Products Regulation
DPP = Digital Product Passport
LLE Coalition = Lang Leve Elektronica Coalitie

EEA = Electrical and electronic appliances
E-waste = Electrical and electronic waste
PLE = Product lifetime extension
DIY = Do it yourself (referring to maintenance or repairment activities that do not necessitate professional help)

BSH = Bosch und Siemens Hausgeräte GmbH

EVT = Expectancy Value Theory (Wigfield & Eccles, 2000)
SDT = Self Determination Theory (Ryan & Deci, 2000) (Ryan & Deci, 2020)
PRIME = PRIME theory of behavior (West & Michie, 2020)
COM-B = COM-B model of behavior (Michie et al., 2011)
FBM = Fogg's Behavior Model (Fogg, 2009), specified by Ackermann et al. (2018)

Executive Summary

The European Union (EU) has adopted the European Green Deal, which aims for its countries to be climate neutral by 2050. A significant problem that should be addressed, in order to reach the EU's goals, is the excessive amount of E-waste that has been increasing over the last decades. This issue can be addressed in multiple ways, however this thesis focuses on the objective of product lifetime extension, through encouraging and therefore improving maintenance behaviors toward electrical and electronic household appliances.

This thesis aims to explore human behavior toward electrical and electronic household appliances (EEA), what can trigger people to perform sufficient periodically recurring maintenance tasks, in order to develop an effective tool for appliance users that are willing to, but not yet performing sufficient maintenance on their EEA in need of periodic maintenance. This objective is formulated through the main research question: **What does an effective communication tool and strategy look like, that can lead targeted EEA users to change behaviors toward better maintenance of their EEA?**

A literature study on maintenance behavior was done by combining the COM-B model of behavior and Fogg's behavior model, which distinguish factors of (cap)ability from factors of motivation. Within this model, several more theory and literature is addressed, identifying concepts like *intrinsic motivation*, *task value*, *task difficulty*, *expectancy of success*, *momentary wants and needs* and *stimuli* and *triggers*.

The project consisted of qualitative research methods, through exploratory interviews with five different experts, each with their own perspective on the field of EEA production, usage, as well as communication about encouraging circular behaviors, specifically regarding maintenance. Moreover, user interviews were performed in order to analyze what triggers and drives maintenance behaviors. This led to specifications for an effective tool design, which was then developed into a final concept and tested on its perceived effectiveness through qualitative validation methods.

It was found that when people lack awareness about maintenance necessity, there is no incentive of trigger that leads them toward sufficient maintenance. There is enough information accessible through various sources, as well as through traditional instruction manuals, however, these sources were only sought out by the participants when they were incentivized by preexisting intrinsic motivations (i.e. upbringing, sustainability). Motivational triggers were found to be most lacking. Lifetime extension was rarely mentioned as a primary motivation for maintenance, instead, short-term triggers (i.e. dirt, noise, lower quality functioning) were found to be effectively triggering maintenance.

The tool concept that was developed are sets of magnetic cards. The cards that were finalized are directed at regular washing machines, but can be extended to multiple different types of EEA. They are meant to trigger awareness and recurring motivation for maintenance tasks. The cards consist of basic instructions, triggering visuals and/or text that both emphasize the negative consequences of non-maintenance and also positive consequences of sufficient maintenance.

The added value of this thesis is that it provides structured insights into periodic maintenance triggers and barriers and provides a practical solution for individuals that lack awareness about required maintenance, as well as triggers to encourage recurring motivation, which were found to be lacking in the current environment.

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Chapter 1
Introduction

'One approach for reducing the environmental impact of today's consumption pattern is to postpone product replacement and therefore use products for a longer period of time'
(Ackermann, 2018)

This thesis is about the maintenance behavior of users of electric and electronic household appliances and how to encourage these users to improve their behaviors towards these appliances, with the goal to extend product lifetimes.

This chapter begins by outlining the **problem definition**, providing an explanation of the issues that the research topic originates from. Following this, the **research questions and aims** are discussed, defining the study's primary goals. Next, the **research process** is described, offering an overview of the methods, steps and iterations of the process throughout this thesis project. The following paragraph describes the **scientific approach**, explaining the background of the two disciplines (IDE and CDI) that guided the process and methodological choices. In addition, the **social and scientific relevance** to the research topic and tool development is described. In conclusion, the report structure is laid out, describing how the **research process** is translated into the different chapters of this report.

1.1 Problem definition

To understand the relevance and context of this research, this paragraph explains the problems that this thesis topic is the result of. The necessity to improve maintenance behaviors can be traced back to the European Green Deal, tackling negative environmental impact, particularly through addressing issues related to product consumption and waste. In doing so, this will provide a foundation for understanding why user maintenance behavior in relation to EEA is relevant for achieving product lifetime extension.

Climate neutral by 2050

In 2019, the European Commission has adopted the European Green Deal (EGD), which ultimately aims to make Europe climate neutral by 2050 by mandating companies to reduce greenhouse gases (European Commission, 2024). To achieve this goal, problems concerning product consumption, use and waste will be addressed.

E-waste & product lifetime

From 1995 to 2022, the amount of electrical and electronic waste (E-waste), including the export of used appliances, released in the Netherlands has more than doubled. In 2022 this amounted to 21 kg per civilian (CLO, 2023). This E-waste largely consists of large equipment according to the CLO, the organization that publicizes facts and figures about the environment, nature and space in the Netherlands (see Figure 1)

All the parts of a product at some point consists of raw materials, and over time ultimately end up as waste. This process is described as the product's lifetime and consists of several stages, which can be described as a linear process. However, each stage can be extended throughout by intervening actions. These actions are usually described as circular processes.

This thesis aims to develop an intervention through improving maintenance behaviors. Encouraging maintenance behaviors is part of the sustainable business model archetype 'encouraging sufficiency' (Bocken et al.,

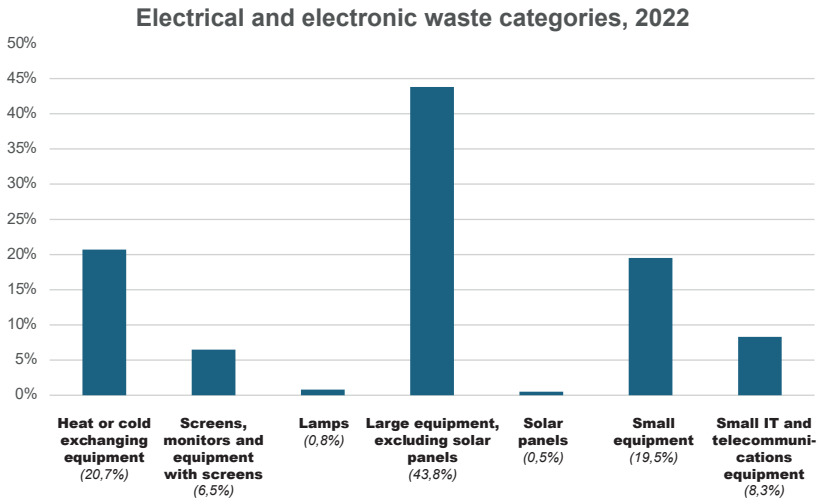


Figure 1 *Electric and electronic waste in the Netherlands in 2022 (CLO, 2023)*

2013) as a way for product lifetime extension (PLE). It has been proven that this positively impacts the reduction of consumption of resources and improves sustainable living for the product user (Bocken et al., 2016). When it takes a longer amount of time for a product to end up as waste, it will take longer for the product to be replaced by a new one. Therefore, it is assumed that extending the product lifetime will result in the reduction of waste over time.

The product life cycle as butterfly diagram

On the topic of product lifecycle expansion through maintenance improvement, it is important to understand some of its originating concepts. Defined by the European Commission in the 2022 Ecodesign Directive, product life cycle means 'the consecutive and interlinked stages of a product's life, consisting of raw material acquisition or generation from natural resources, pre-processing, manufacturing, storage, distribution, installation, use, maintenance, repair, upgrading, refurbishment and re-use, and end-of-life' (European Commission, 2022). The linear processes within a product lifetime are made circular through intervening actions. The Ellen MacArthur Foundation has visualized this in 2015 (see Figure 2).

The circular economy system diagram, known as the butterfly diagram, illustrates the continuous flow of materials in a circular economy (Ellen McArthur Foundation, 2019), instead of a linear economy, where materials can only end up as waste. Maintenance is one of the first and most direct actions the user of a product can actively extend the product lifetime as it is visualized within this diagram.

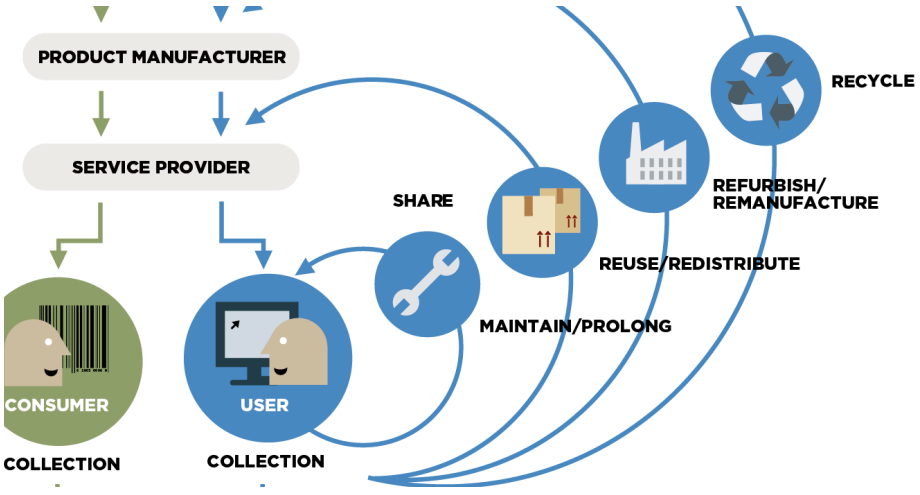


Figure 2 *'User activities' section of the Butterfly Diagram (Ellen McArthur Foundation, 2019)*

1.2 Research aims and questions

The research aims to explore, analyze and improve the manner in which EEA users behave around their appliances. This was structured by formulating a main research question, and following that, formulating four separate sub questions that, following a chronological structure of subsequently four phases, would answer the main research question. Figure 3 illustrates an overview of this structure. The number of phases being four was chosen based on the double diamond method (Design Council, 2025), which is further explained in paragraph 1.3 Research process.

The main research question of this thesis is: **What does an effective communication tool and strategy look like, that can lead targeted EEA users to change behaviors towards better maintenance of their EEA?**

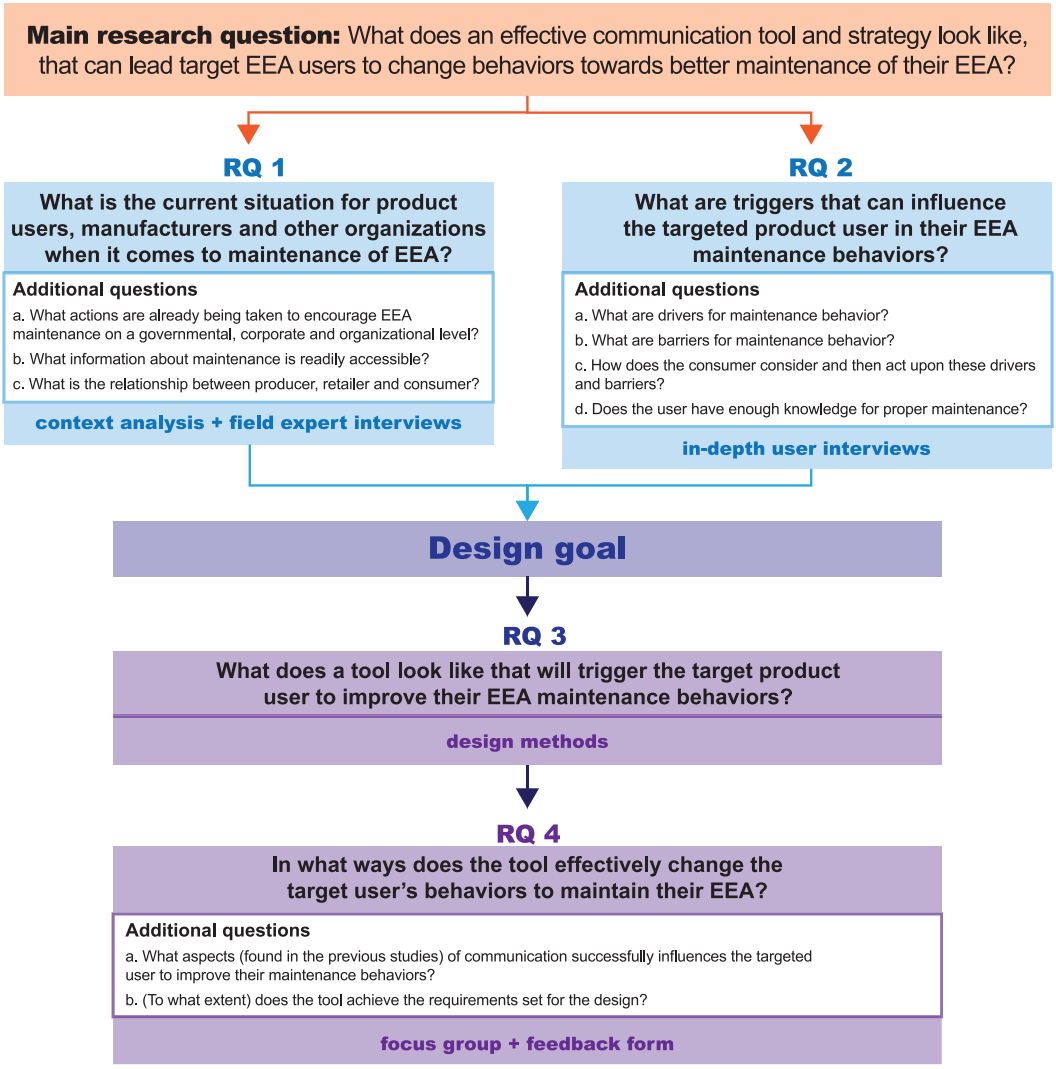


Figure 3 *Research structure overview*

The project was divided into four different phases, the first one being exploratory. The aim here was to explore the topic of EEA maintenance and obtain a general sense of the context around maintenance behaviors and the current situation regarding the relations between users, manufacturers and other organizations. The actions taken to achieve this started with a context analysis, which is laid out in Chapter 2 Context Analysis. Along with the context analysis, field experts were interviewed, of which the method and results can be found in Chapter 3 Field Expert Perspectives. The research question that was formulated for these actions to answer is:

RQ 1. **What is the current situation for product users, manufacturers and other organizations when it comes to maintenance of EEA?**

The second study was conducted through a semi-structured interview approach with regular appliance users . The interview questions are based on a theoretical framework for behavior, aiming to obtain an in-depth user's perspective on EEA maintenance behaviors. The interviews were conducted, and the results were discussed, in order to answer the following research question:

RQ 2. **What are triggers that can influence the target product user in their EEA maintenance behaviors?**

With the results and conclusions of these two studies, design specifications were set up, concluding in a design goal. This resulted, through a creative design phase, into the development of the communication tool. This was done so using the following research question:

RQ 3. **What does a tool look like that will trigger the target product user to improve their EEA maintenance behaviors?**

The tool was then tested on its effectiveness through one focus group session and a short feedback form, for obtaining both feedback on the effectiveness validation, as well as for making final improvements of the tool. In this final phase, it was aimed to answer the following research question:

RQ 4. **In what ways does the tool effectively change the target user's behaviors to maintain their EEA?**

1.3 Research process

The research process was structured following the Double Diamond Method (Design Council, 2025). The process is made up of four stages, which are visualized into two diamonds to illustrate the divergent and convergent phases of thinking, as visualized in Figure 4.

The reporting started by writing the research proposal. Halfway through the project, a midterm document was written by reporting on the methods and results for the first two research questions. After that, the problem definition and concept development stages were executed, answering the third research question. This was documented into the greenlight report, which led to the finalization of the concept and the final thesis report.

The process started with an exploration phase. This consisted of context analysis (chapter 2) and field expert interviews (chapter 3). With the results and insights from this exploration stage together with the insights from the literature study on maintenance behavior (chapter 4), the in-depth user interviews (chapter 5) were set up and conducted.

The process is visualized in chronological order, but the figure also visualizes four iterations with circular arrows. An iteration in the context of this process figure means that two activities did not just chronologically follow each other, but that they both influenced each other by going back and forth between the activities. Although the whole process continuously consisted of iterations, there are four specific notable ones.

- **Iteration 1** describes how the process of context analysis was intertwined with the field expert interviews, due to them both being exploratory in nature, both aiming to answer RQ1.
- **Iteration 2** was the process of setting up design specifications (chapter 7) and the brainstorming process (chapter 8). At this stage, literature for the theoretical framework for intervention design (chapter 6) was also formed. All three of these activities influenced each other as an iterative process.
- **Iteration 3 and 4** are supposed to illustrate how the process of conceptualization was first intertwined with

prototyping, as well as the following process of validating the design. These activities all influenced each other in order to present a final concept.

This thesis project started with a literature study into topics of behavioral science, sustainability intervention and design for the circular economy. At this point, the structure for the project was set up for the research proposal, and the decision was made to start the process with conducting both unstructured and semi-structured interviews. The literature study was initially meant to aid the setting up of the interview questions. This was documented in the mid-term report. After that, the choice was made to divide the literature study into two separate parts, as it became relevant to look into intervention design literature, to aid the second half of the project.

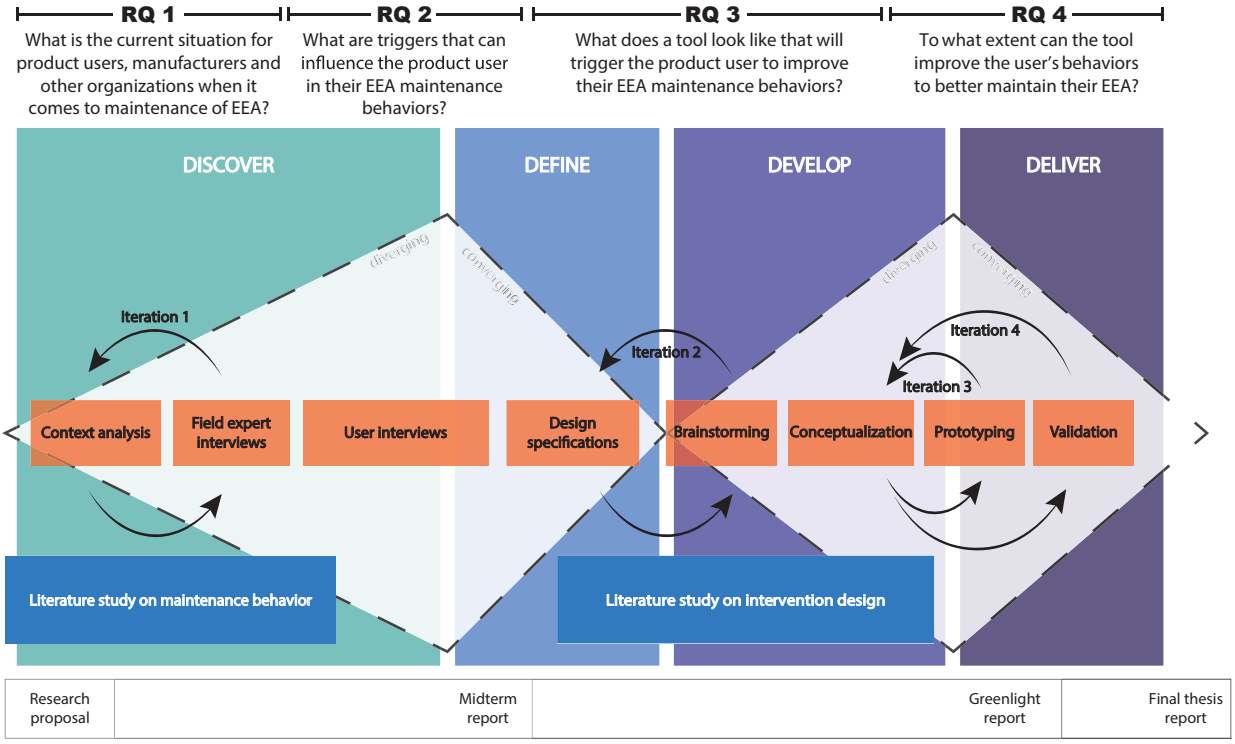


Figure 4 *Visualization of the research process as a double diamond*

1.4 Scientific approach

The scientific approaches applied throughout the project were guided by two disciplinary perspectives: Industrial Design Engineering (IDE) and Communication Design for Innovation (CDI). IDE aims to understand user needs and develop solutions through products, services, or systems, in order to improve human interactions and experiences. CDI focuses on analyzing existing contexts to understand how technology and innovation impact human behavior, aiming to improve communication and social interactions within these environments.

Although there is considerable overlap, IDE approaches are focused on design methodology, which focuses on the creation of tangible products, services, and systems, while CDI seeks to understand and improve communication processes with the focus on social dynamics within complex, technology-driven contexts. Despite their different styles, the approaches are not mutually exclusive, either field may arrive at similar solutions.

As mentioned in the previous paragraph, the research process was divided into two parts. The first half of the project focused on social scientific research, using unstructured and semi-structured interviews to explore aspects of human behavior related to EEA. A theoretical framework for the interviews, based on behavioral literature, structured the research methods. Unstructured interviews gathered expert insights from stakeholders connected to the Ministry of Infrastructure and Water Management (I&W) and the LLE coalition. The analysis of the interviews was based on the CDI approach, emphasizing the understanding of behaviors and interactions within the social and technological context of EEA maintenance.

The second part of the project focused on developing the tool through several iterations, leading to the final presentation of both the tool and the strategy. The methods used during these phases were drawn from the Delft Design Guide (Van Boeijen et al., 2013), forming the basis of the IDE approaches applied throughout the second half of the project. The selected methods are applied throughout Chapter 7 Design Scope and Chapter 8 Tool Development, for example the use of How-Tos, the Harris Profile, the Weighted Objectives Method, and prototyping.

1.5 Social and scientific relevance

The increasing amount of E-waste over the past decades (CLO, 2023) demands for creative solutions, one approach for this being behavioral intervention (Abrahamse et al., 2005). There is an increasing governmental (European Commission, 2022; New Foresight, 2023), societal (Bocken et al., 2018; Repaircafe, 2024) and also business (Bocken et al., 2013; BlueMovement. 2024) demand for circular practices, of which maintenance is an essential activity, as part of the use-phase of a product where user behavior is essential (Ellen McArthur Foundation, 2019). This thesis adds to the existing research into EEA use and specifically care behaviors (Ackermann et al., 2018; Torca-Adell et al., 2024), specifically aiming to understand what drives and triggers people toward performing periodical maintenance tasks, which necessitate recurring motivation for the requiring behavior from the user.

The developed tool brigdes the gap between users willing to perform PLE activities, but who simultaneously do not have the awareness, nor recurring reminders in their environment that encourage them to perform maintenance tasks.

Based on the behavioral research, the tool aims form EEA owners to have their EEA last longer, and therefore to postpone product replacement. This is one approach for reducing the environmental impact of today's consumption pattern (Ackermann, 2018) that has resulted in an increasing amount of E-waste over the past decades.

1.6 Report structure

The chapters in this report are structured by order of each research question. It starts with the introduction, where general information about this research project has been explained. This is followed by chapter 2, which begins to answer RQ1, by presenting findings of the online desk and research into the context of EEA maintenance. Chapter 3 then follows by providing further insight into RQ1, with field expert perspectives that were obtained through unstructured interviews. Chapter 4 provides an overview of the theoretical framework for maintenance behavior, that was mainly used to set up the in-depth user interviews, of which chapter 5 provides an extensive explanations of the methods, results and interpretations. Chapter 6 presents a separate theoretical framework, focused on intervention design. This framework, in combination with the findings from the prior research, is then used to set up the design scope in chapter 7, and consequently develop the communication tool, using several design methods, and concludes with presenting the validation methods that were done. of which the process is shown in chapter 8. Chapter 9 then presents the each element of the final tool concept and strategy for implementation.

Chapters 10 is the discussion about the meaning and relevance of the research, followed by chapter 11, where answers to each of the research questions are concluded.

In addition to the general Chapters 2, 3 and 5 end with a list of the main takeaways from the results and findings that are presented in the corresponding chapters. These takeaways are what relate the findings from RQ1 and RQ2 to the main research question, and are therefore used in the conceptualization and development of the final communication tool and strategy.

Chapter 2
Context Analysis

This chapter provides an overview of the regulatory and practical context analysis of the initial assignment, which originates from the EEA coalition action plan (New Foresight, 2023). The insights from this chapter came from online desk research using sources from the European Commission about regulations, accessible information about practice examples related to scientific research and accessible data that EEA businesses and related organizations currently provide online. In addition to these online sources, unstructured interviews with field experts were conducted, which are presented in Chapter 3 Field Expert Perspectives. Chapter 2 and 3 both aim to answer the first research question, with this chapter specifically focusing on RQ1a and RQ1b:

RQ 1. **What is the current situation for product users, manufacturers and other organizations when it comes to maintenance of EEA?**

RQ1a. What actions are already being taken to encourage EEA maintenance on a governmental, corporate and organizational level?

RQ1b. What information about maintenance is readily accessible?

The chapter starts by examining **governmental regulation and initiatives**, focusing on European Union regulations and Dutch government policies that have led to or impacted this thesis topic. Following that, the **research scope** is specified by discussing the definition of maintenance as part of the use phase of appliances, and the mapping of the appliances that require maintenance, ascribing categorizations for different maintenance activities based on effort and frequency. The targeted product user is also shortly discussed. Following that, the chapter discusses the **accessibility of maintenance information**. The following paragraph goes over some examples of **practices related to maintenance encouragement**, like Product as a Service business model implementations and the Repair Café.

In the final paragraph of this chapter, the main takeaways for development of the communication tool are mentioned and argued for. These are insights that were used for decisions later in the process, as described in paragraph 1.3 Research process. This is meant to provide insights into the process of answering the main research question and how this first phase have become relevant in the design phase later on (see chapters 7 to 11).



2.1 Governmental regulation and initiative

In order to understand the context of EEA maintenance, it is relevant to analyze the origin of this thesis assignment. The assignment originally was formulated by the EEA coalition, as part of a larger agenda initiated by the Dutch Government, which all follow the European Union's regulations that aim for a complete circular economy.

European Union regulations

On the 11th of December 2019, the European Green Deal (EGD) was adopted by the European Commission, which ultimately aims to make Europe climate neutral by 2050, by mandating companies to reduce greenhouse gases (European Commission, 2024). As a result of the EGD, several agreements, initiatives and regulations have been introduced, for example, the New Circular Economy Action Plan (NCEAP) in 2020, the Ecodesign for Sustainable Products Regulation (ESPR), which includes the implementation of digital product passports (DPP), and the Right to Repair (European Commission, 2024a).

The Ecodesign Requirements for Sustainable Products and Repealing Directive was introduced in 2022. In this directive, concepts like durability, reliability, reusability, upgradability, reparability and possibility of maintenance and refurbishment are set out as requirements for sustainable products (European Commission, 2022). With this directive, the EU also wants to stimulate businesses to shift towards circularity by enforcing 'direct benefits to the competitiveness of businesses, including a shift of activity from the processing of primary towards secondary raw materials and from production of products to maintenance, re-use, refurbishment, repair and second-hand sales, which is expected to benefit SMEs significantly because they are more active in these sectors' (European Commission, 2022), meaning that businesses will have to invest in circular economy strategies and practices, for instance, improving maintenance behaviors.

The regulations also state that 'nearly all products sold in the EU' will be required to feature a digital product passport (DPP), in order to 'enhance transparency across product value chains by providing comprehensive information about each product's origin, materials, environmental impact, and disposal recommendations' (Data.Europa.Eu, 2024). These actions demand increased transparency from businesses to consumers and aim to provide better ways for consumers to have reliable product information accessible.

Another notable directive is the *right to repair* (European Commission, 2023), which is supposed to ensure manufacturers to provide sufficient repair services, opportunities and information for consumers (Europees Parlement, 2020; European Parliament, 2024). Repairment and maintenance are often viewed as very similar to each other, especially when considering DIY repair activities. One example of this is how the butterfly diagram (see Figure 2) groups them together as 'maintain/prolong' activity.

These regulations imply that businesses will have to shift from linear economy towards circular economy business models. This provides the opportunities for collaboration between businesses and organizations aiming to encourage consumers to shift towards circular behaviors as well.

Dutch government

In 2023, New Foresight published the action plan for the EEA Coalitie, now known as the Lang Leve Elektronica (LLE) coalitie. This coalition was formed to speed up the transition to a circular economy within the EEA sector, initiated by the Ministry of Infrastructure and Water Management as part of the 'Transitieagenda Consumptiegoederen' in collaboration with Het Groene Brein (New Foresight, 2023). The LLE coalition separates this action plan into five icon projects: Repairment, second-hand, refurbishment, shared use and maintenance (see Figure 5).

Partners in this coalition focusing on maintenance are Miele, Repaircafé, TU Delft, BSH, Applia, Witgoedbrigade and Het Groene Brein. From this coalition, in collaboration with the icon project of maintenance, the initial assignment for this research was drafted, supervised by Roos Janssen from Het Groene Brein, and Daniëlle Broeze from the Ministry of Infrastructure and Water Management.

Why maintenance?

This study focuses on maintenance behaviors as a way to optimize the use phase of EEA, in other words to extend the product lifetime. This is just one of five different icon projects, which are summarized in Figure 5.

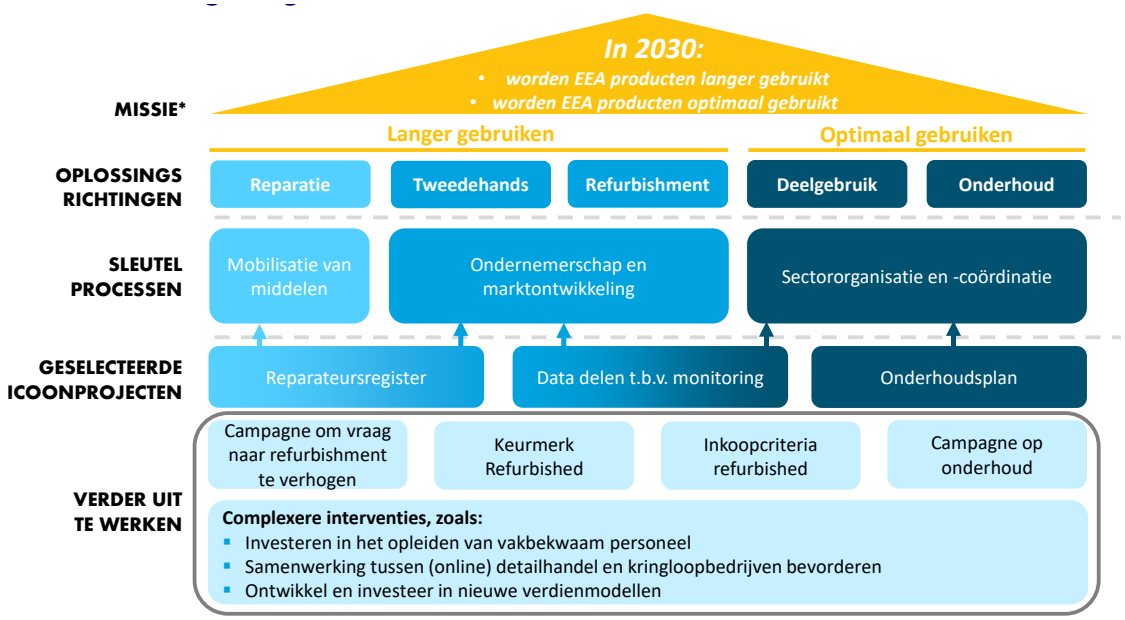


Figure 5 *Summary of the EEA coalition icon projects (New Foresight, 2023)*

As part of the EEA coalition's icon projects, maintenance falls under their mission of making sure that EEA will be used optimally by 2030 (New Foresight, 2023). In doing so, they distinguish two types of intervention types: Longer use and optimal use. While these categories are separate, optimal use naturally contributes to longer use. It is assumed that optimal use primarily focuses on user behavior interventions, which is the main focus of this research, by aiming to encourage behavior that extends product lifetimes, or in other words, supports longer use.

2.2 Research scope

The topic of EEA maintenance, user behaviors and ways of communication about these things can be up for discussion. Questions may come up like, where does maintenance begin and where does it end? What is the difference between repairment and maintenance? Does maintenance include proper installment or even use, like charging your laptop only up to 79%, or installing your washing machine the correct way? Moreover, the category of EEA has a wide variety of different appliances that are also grouped into different maintenance types. To answer these questions, this paragraph will define the scope that this thesis research will focus on.

Defining maintenance

Defined by the European Commission, maintenance is 'an action carried out to keep a product in a condition where it is able to function as required', and durability is 'the ability of a product to function as required, under specified conditions of use, maintenance and repair, until a limiting event prevents its functioning' (European Commission, 2022).

What activities can be considered maintenance is not the same for each individual. It is assumed that there may be considered some grey area that overlaps with proper installment, regular appliance use activities and DIY repair. The definition from Oxford Languages for the regular word 'maintenance' is 'the process of preserving a condition or situation or the state of being preserved,' which still could be interpreted broadly. As an example,

Rob Walthaus, service manager at BSH, when talking about maintenance activities, mentioned the following:

> *'If you look at pump blockage places within a device, it often has to do with items that have been left out in the clothing, or a coin, or something else that causes a pump blockage. That's just a matter of solving it yourself, if you're handy enough.' (Rob Walthaus, 2024)*

Figure 6 shows an outline of the European Commission's definition of maintenance, its possibly perceived overlap with other phases of product use, and the grey area that comes with it.

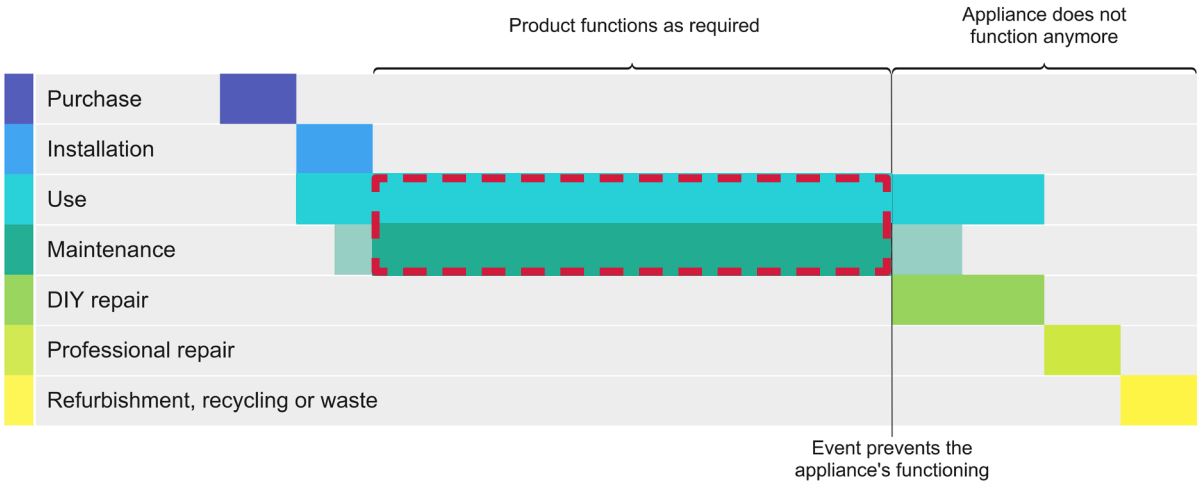


Figure 6 *Visualization of the phases of product use*

The main focus of this research is marked with the red dotted line in the Figure 6. This is the period when the product functions as required, and in which the user can take action to perform maintenance activities, and therefore it is assumed that this is where behavioral research is most of value. Therefore, this area is specifically relevant for this research. The goal of this thesis project is to search for ways to encourage EEA users to perform better maintenance and extend this period of time.

Maintenance categorizations

To determine the types of maintenance that a product owner has to perform, the relevant products and their maintenance activities were mapped in Miro (see Figure 7). From this, five main categories of maintenance were derived, with an additional sixth that is within the grey area overlapping with repairment. The categories are listed in Table 1.

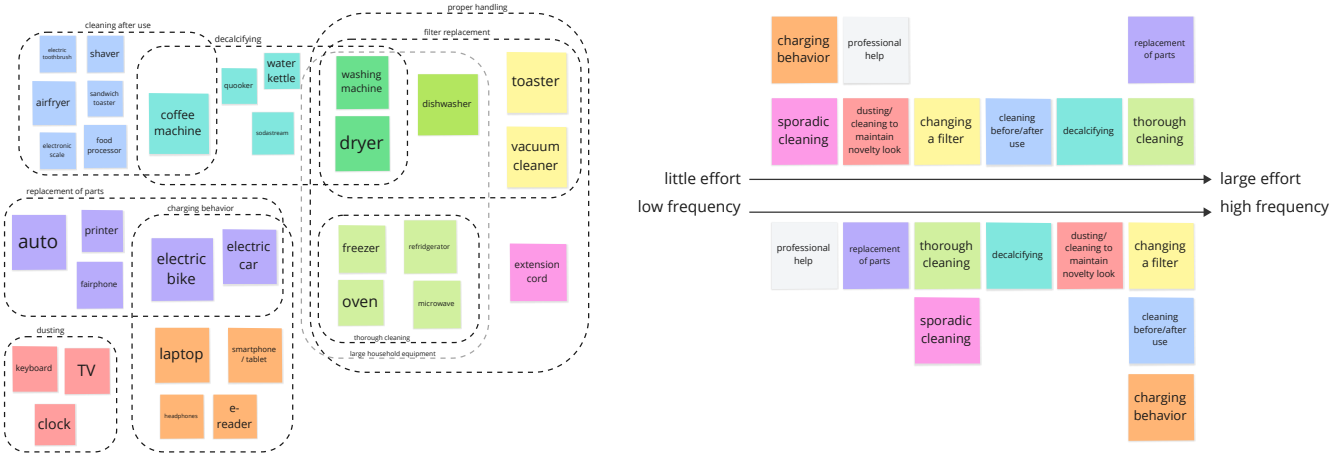


Figure 7 *Maintenance activities and product categorizations (see Appendix A for full images)*

Maintenance category	Sub category
1. Cleaning per use	a. Filter Replacement b. Rinsing parts
2. Cleaning per longer period (periodic maintenance)	a. Decalcification b. Automatic flushing c. Thorough cleaning once in a while
3. Dusting/cleaning to maintain novelty look	
4. Normal' handling of the appliance	a. Charging behavior b. (re)placement c. Use it for what it's intended for
5. Professional help	
6. Replacement of parts (repairment)	

Table 1 *Maintenance categorizations*

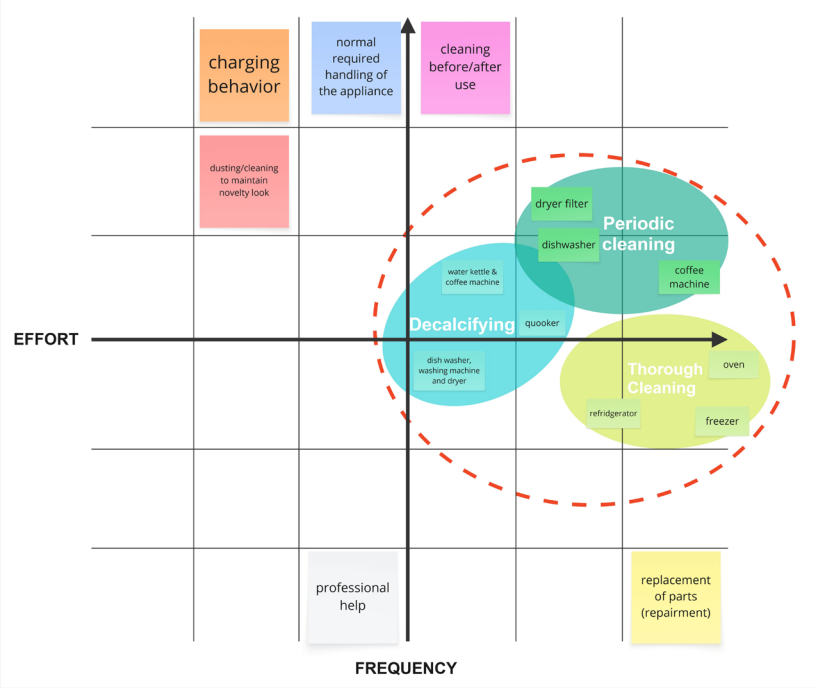


Figure 8 *Maintenance categorizations over 2 axes of 'effort' and 'frequency'*

In the Figure 8, the maintenance types are mapped onto an x- and y-axis with the amount of effort on the x-axis and the frequency of the necessary action on the y-axis. The positioning of the categories on the map was determined based on accessible information about the maintenance activities, personal experiences and intuition. The red dotted circle contains the categories that the research will focus on, showing that they are similar to each other, because of their proximity to each other on this graph.

The scope of this research will be focused on the second category of Table 1, which is periodic maintenance that either takes much or little effort to perform, because it is assumed that this is where motivation is especially lacking. The assumption is that periodic maintenance is something that can easily be forgotten, and direct results are not experienced in the short-term. For that reason, it is found to be interesting to research the drivers and barriers for behavior of periodic maintenance.

However, getting a clear view of the distinctions between all of these categories is relevant, therefore the interview topics are not strictly limited to the second category. The interviews will have open ended questions, which can relate to any of the categories, but the focus of follow-up questions are about the second category.

Target user

In the starting phase of this research project, the target user was not yet specified in detail, specifically up until the interviews. This decision was made in order to have the possibility to define a more specified target user later on in for design goal. Therefore, a more detailed description and discussion about the target user for the design phase can be found in Chapter 7 Design Scope.

A characteristic of the target users that was specified for the user interviews, was targeting people that are already open to the idea of sustainable behaviors but are not yet performing this behavior. This was argued for during the exploratory interview with a behavioral researcher at Milieu Centraal, which will be discussed in Chapter 3 Field Expert Perspectives.

Moreover, households with no more than three individuals responsible maintenance of the EEA, were the target for the interview participants. This choice was made so that there is a somewhat clear agreement about responsibilities for maintenance within the households of the participants interviewed. This way, the participants were assumed to speak more thoughtfully about personal drivers and barriers for maintenance behavior.

When this report further on (until specification in Chapter 7 Design Scope) mentions the EEA user, these are the characteristics that are meant to be ascribed.

2.3 Access to maintenance information

In this paragraph, the accessibility to maintenance information for regular consumers is discussed. Some examples of businesses that are already taking steps toward developing more efficient ways of communicating with their customers are BSH, Miele, Witgoedbrigade. They are doing this with the use of apps, AI generated help and internet connected devices. There are several more ways of acquiring information on how to maintain one's own appliances, which are listed in Table 2, including who distributes the information, whether it is provided through digital or non-digital media or both, as well as examples.

Information medium	Distributer	Digital/non-digital/both	Examples
Instruction manual	Provided by manufacturer	Both	Comes with the new product, also accessible online
Online blogs	Provided by either manufacturers, retailers or neutral parties	Digital	Websites: BlueMovement, Consumentenbond, HG
Apps	Provided by manufacturers	Digital	BSH app
Online chatbots and customer services	Provided by either manufacturers, retailers or neutral parties	Digital	Witgoedbrigade Chatbot Bram
Instructional videos	Provided by manufacturers, retailers and neutral parties	Digital	YouTube and Google search results
In-person communication	Provided by peers	Non-digital	Anecdotal

Table 2 *Accessible sources for maintenance information*

Instruction manual

The main non-digital source for maintenance instructions is the instruction manual. Every new appliance comes with one and must meet a set of requirements, depending on the type of product, aiming to ensure 'safety and conformity of products within the EU market.' Generally, these requirements include providing 'information on routine maintenance tasks, including cleaning, lubrication, and replacement of consumable parts' and 'recommended maintenance schedules' (Certification Experts, 2023). However, the general outline of the user manual includes much more information like, among other things: Product identification, intended use, safety

precautions and warnings, installation, setup and operation instructions, technical specifications and warranty information. Moreover, the manual often comes in several different languages. It can be concluded that the main objective of this user manual is to provide information to the user, not only about maintenance. This results in a condensed booklet that lacks the objective specifically to motivate the user towards maintenance behaviors.

While the user manual may consist of all the specific information that is necessary to perform the proper maintenance on the product, there is an opportunity for non-digital, accessible maintenance information, which focuses on motivational aspects of maintenance behavior. The reasons behind the importance of a combination of accessible information and motivational triggers are elaborated in Chapter 4 Theoretical Framework for Maintenance Behavior.

Online sources

When it comes to digital aid, it is assumed that, when the first attempts don't work out, the appliance user would use a research engine to acquire information on maintenance. Figure 9 shows some of the online information sources that are accessible through search engines.

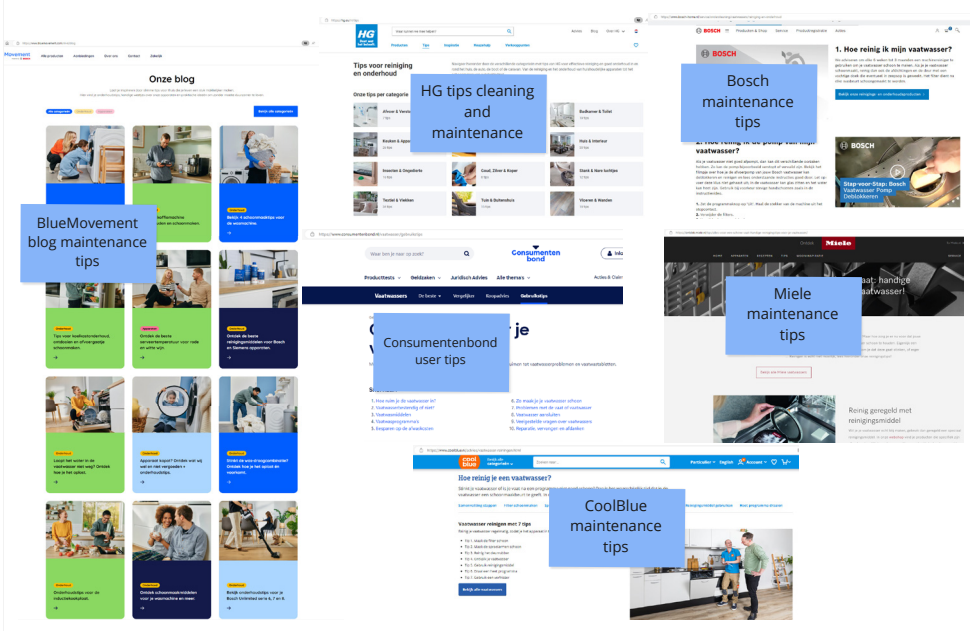


Figure 9 *Examples of online information sources about appliance maintenance (BlueMovement. 2024), (HG., n.d.), (Van Steijn & Consumentenbond, 2024), (Bosch, n.d.), (Miele, 2024), (Chiara & CoolBlue, 2025)*

What should be taken into consideration is that these types of digital aid take initiative from the consumer. If not motivated to search for more information or to acquire more knowledge about maintenance, it is assumed that the user would most likely not perform the necessary maintenance. A problem that comes with this is when the user is not aware that they lack knowledge, that they will not be inclined to go looking for it. It can be concluded that there is an opportunity to incentivize the user to take this initiative, at least by bringing awareness first.

Apps

In the interview with a service manager at BSH (see Chapter 3 Field Expert Perspectives), he talked about the Home Connect app (see Figure 10) that they have developed, explaining that through the app, tips and advice are given about cleaning where 'customers can control their smart kitchen and household appliances easily and simply.' Customers can click directly on the videos and the maintenance options that are available or solve it yourself for malfunctions. He also said that in the future, connected devices will offer even more solutions for consumers to do things themselves and for manufacturers to have close contact with the consumer, by adapting the app with tips and advice and supporting customers based on their questions.

On the other hand, there is the AI chatbot from Witgoedbrigade called Bram (see Figure 11). This chatbot enables users to ask questions about their appliances.

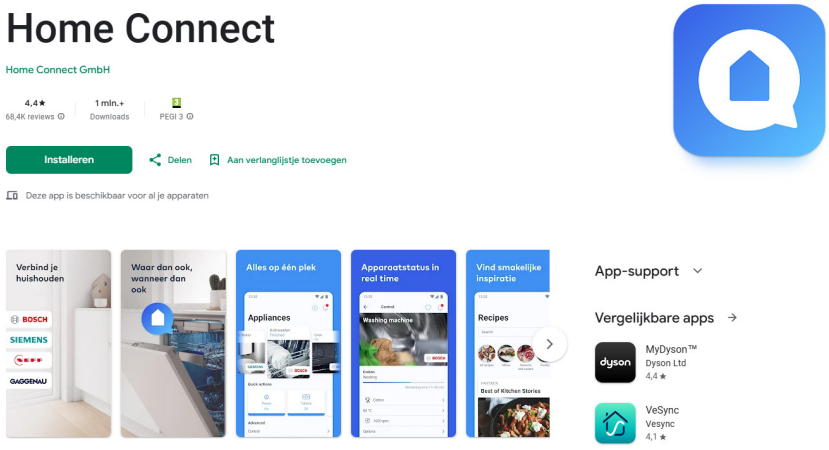


Figure 10 *Home Connect app in Google Play store (Home Connect - Apps op Google Play, n.d.)*



Figure 11 *Chatbot Bram (Witgoed Brigade, 2024)*

2.4 Maintenance encouragement practices

In this paragraph, three different examples are given of practical examples that are currently successful or relate to achieving maintenance encouragement. First, examples of the circular business model Product as a Service are explained. Next, it is explained how the success of the Repair Café illustrates the demand from regular users for circular behaviors and portrays opportunities for encouraging maintenance. Following that, the Product Care Kit is explained, which is a tool meant to be used by designers, for inspiration to encourage product care, like maintenance.

Product as a service (PaaS) - The product as a service business model shifts the ownership of products from the customer to service provider, making it a circular business model. The model enables companies to ensure circular activities more efficiently, like repairment and recycling, but also incentivizes the companies to ensure better maintenance. Although this increase of incentive for the companies can be considered as a positive result, the possible decrease of incentive for customers could have a negative influence on maintenance behaviors, because ownership has been shown to have positive influence on product care (Tunn & Ackermann, 2020). Examples of businesses that provide a rental-lease construction for household appliances are Homie (Homie, 2025), Splash Lease (Splash Lease, 2025) who exclusively rent to students, and also Meo Lease (Meo Lease, 2025).

Homie follows the pay-per-use business model, which is where consumers pay for the unit of service, instead of ownership of a product. With the pay per use model, incentives for companies to take responsibility for product life cycle is increased (Bocken et al., 2018), for instance regarding maintenance activities. It was also proven that through this model, consumers become more conscious about their own consumption behaviors.

Repair Café - The Repair Café is an example of an organization that aims to help regular appliance owners in extending the product lifetime, by offering opportunities to local communities to organize the so-called Repair Café, where either professional or skilled amateur repairmen are offering to repair any appliance that someone would bring to the *cafe* setting. Starting in 2007, this has been growing ever since. On their website they mention that in addition to the Netherlands, there are also Repair Cafés in other countries in Europe, the United States and other countries around the world (Repaircafe, 2024). The founder of the Repair Café had mentioned that maintenance as the cause of damage is often overlooked by the owners. The growing success of the Repair Café illustrates the necessity for improving EEA maintenance, and also the opportunity for preventative measures, like encouraging maintenance, instead of mainly offering help with repairment.

Product Care Kit - As part of her master thesis, Mahana Tuimaka, with supervision from Laura Ackermann, developed a Product Care Kit that use to learn about consumer interaction with products in the context of product care, as well as inspiration on how to design for it (Ackermann, Tuimaka et al., 2021). The kit distinguishes 7 product care types, 8 design strategies and also provides persona and product cards, all including examples given. The product care types are as follows: (1) Repair, (2) creating something new/different, (3) product revival, (4) preventive measures, (5) small care, (6) instructed & mindful handling and (7) routine acts. This thesis focuses on product maintenance behaviors, concerning opportunities for product care during the use phase of a product lifecycle, before repairment would be deemed necessary. Product care type 1 and 2 are not relevant for this study, however the distinctions between numbers 3 to 7 are used in following chapters.

MAIN TAKEAWAYS FOR TOOL DEVELOPMENT

1. The main focus of this research and therefore also for the final tool concept is chosen to be **the period when the product functions as required**, in which the user can take action to perform maintenance activities.
2. The decision is made to focus on **periodic maintenance**, because when maintenance tasks are categorized based on amount of effort and frequency of necessary action, these are assumed to be where motivation is tends to be lacking.
3. The final intervention and strategy will enable the upcoming mandatory **Digital Product Passport** (DPP) to be accessed, because businesses will require to provide this access and are therefore already incentivized for this cause.
4. The long-term strategy that goes with the final tool concept will aim to encourage circular user behaviors and in doing so will enable **collaboration between businesses and organizations**, since new regulations have made businesses increasingly **aware of the necessity** for circular actions by requiring more transparency and to communicate reliable data to consumers.
5. The tool should emphasize **motivational aspects,** encouraging maintenance activities. This is currently missing in user manuals, which contain all the required and necessary information about the appliance, not mainly focused on maintenance, and also not specifically aiming to motivate maintenance behavior. As a result, it often becomes a condensed booklet that lacks elements for persuading (maintenance) behaviors.
6. A requirement of the tool will be to **bring awareness about necessary maintenance**, since this is essential for motivating behavior change. Currently, seeking out maintenance information currently requires consumers to initiative and without awareness of their knowledge gaps, they are unlikely to take action.

Chapter 3
Field Expert Perspectives

As has been discussed in the previous chapter, when it comes to maintenance behavior from regular product users, it is important to understand the context that the user is present in. It is clear that there are actions being taken by different parties to inform the users about what maintenance is necessary for most EEA. In addition to the findings from the previous chapter, unstructured interviews were held with field experts, in order to get a deeper understanding of the current sitiation, and to analyze the different perspectives of experts within the field of EEA maintenance. This was done aiming to get a deeper understanding of the topic, relating to RQ1 and RQa, and with additional question RQ1c, to explore the relationship between producer, retailer and consumer.

RQ1	**What is the current situation for product users, manufacturers and other organizations when it comes to maintenance of EEA?**
RQ1 a.	What actions are already being taken to encourage EEA maintenance on a governmental, corporate and organizational level?
RQ1 c.	What is the relationship between the producer, retailer and consumer?

This chapter first goes into the interview **method** and then the **results** relevant for this exploratory phase. The results are split into three different perspectives - user oriented, business oriented and the more general insights about (maintenance) tools and information - with a total of six topics for discussion. The **interpretations** of the results are discussed in the following paragraph.



3.1 Methodology

Participants

A total of six people were interviewed, each with different perspectives within the field. The field experts were contacted through connections within the EEA coalition and with the help of the Behavioral Insights Team (BIT) at the Ministry I&W. This made it possible to get in contact with a variety of different stakeholders with expert knowledge in the field of EEA production, communication and maintenance. In addition, companies like HG, Eccellente and waterfilter.nl, specialized exclusively in maintenance tools were also contacted via email, however, these companies either did not respond or declined to participate.

The first interview was with the service manager at BSH, who had in-depth knowledge about what types of maintenance issues are most prevalent, and what causes and solves most of these issues, mostly from a business perspective. For a consumer and communication perspective, a strategic communication advisor as well as a behavioral researcher at Milieu Centraal were interviewed. Moreover, to get an idea about the DIY side of user maintenance behaviors, two participants involved with the organization of Repair Café and also as an independent repair professional, experienced in giving repair workshops, were interviewed.

Interview preparation

Unstructured interviews were chosen as the method approach for this phase. Characteristics of a unstructured interview are the use of a topic list instead of written out questions. These topics were discussed in the interviews, but the specific way or order in which they were discussed was not determined (Mathijssen, 2024). This approach was chosen due to this phase being exploratory in nature. Therefore, the belief was that pre-written questions would be too constraining to the conversations. The topics that were prepared for the exploratory interviews are as follows:

- **The relationship between retailer, producer and customer** - apart from retail, especially with regard to communication, services, etc.
- **Incentives for the producer** - related to encouraging the consumer to maintain the product
- **Knowledge available/provided to the consumer** - knowledge for proper maintenance
- **Possibilities or barriers for maintenance** - with regard to improving the user's maintenance behaviors

Conducting the interviews

All interviews were recorded, transcribed, and subsequently coded. The interview with the two representatives of Repair Café was held in-person and lasted for approximately 2 hours. The remaining interviews were conducted via digital Teams meetings, each lasting between 1 and 1.5 hours. All interviews were conducted in Dutch, therefore the transcripts are also in Dutch. The citations in this chapter are translated to English. At the beginning of each interview, all participants were asked for consent for the meeting to be recorded and for their personal transcription data to be used in this research paper.

Data analysis

The exploratory interview transcripts were analyzed using coding software Atlas.ti. Codes were compiled based on thematic analysis, using an inductive coding approach. Six different topics were identified, which were then divided into three categories. This is shown in Table 3. Both the codes and the topics were ascribed based on themes relevant for the defined research scope and intuitively on their relation to the research goals.

Further details about the codes, themes and corresponding citations can be found in Appendix B.

Category	Description	Topics	Description
1. User oriented	Insights into the behaviors and motivations of consumers (from an expert perspective), exploring what drives them to (not) take responsibility for maintenance.	*Capability*	Remarks on what the user can do themselves and what they are expected to be capable of by themselves, without professional help.
		Reach	Characteristics of the type of users that are best to reach out to for behavior change and on what (could) motivate(s) them.
2. Business oriented	The perspective on how companies and organizations are (or will be) dealing with the demand to shift towards a circular economy.	*Steps toward circularity*	Insights into the shift that is happening for companies and organizations toward a circular approach.
		Ownership	Remarks made about the benefits and the influence of shifting ownership to businesses.
3. Tools and information	Addresses the role of information, communication and tool accessibility in enabling sufficient maintenance.	*Awareness and initiative*	Insights into the relationship between awareness of necessary maintenance, accessible sources of information and whether someone will take the initiative to look beyond the instruction manual.
		Neutrality	Remarks about prescribed maintenance tools and products from manufacturers and whether alternative options are reliable.

Table 3 *Field expert interviews data analysis categorizations and topic selection structure*

3.2 Results

1. User oriented

a. Capability: The consumer is capable of more than they often think themselves.

The capability of consumers to maintain and repair their own electrical appliances is generally underestimated. BSH's service manager mentioned:

"Everything you can do without tools you could leave to customer, but it has to be done in a way that is easily accessible."

Another expert, someone who regularly gives repair workshops, also mentioned that he thinks you can help people by giving them better information, proposing that it should to become a kind of routine that you do every day and is easy, so that at some point you don't really have to think about it anymore.

One of the interviewees from Repair Café mentioned the common tendency for individuals to overlook simple issues, such as a clogged filter in a vacuum cleaner, leading them to prematurely deem their appliances broken, mentioning if they are encouraged to replace the filter and then they then notice the sound is gone and it works again, they start to understand that they can do something themselves and realize they have to take good care of it. In the conversation with Repair Café, they suggested that when people realize how basic maintenance tasks can resolve issues, they gain confidence in their ability to care for their appliances.

The repair workshop expert further argued that almost everyone who comes to him has brought something they have had lying around for more than a year. That means that they do want to do it, but that there is somehow something that is holding them back. He argues that providing consumers with better information is helpful and the development of a routine is essential for successful maintenance. He mentions how people will delay repairs despite possessing the desire to fix their appliances. Overcoming initial barriers, such as lack of knowledge or confidence, could be a solution for this.

b. Reach: The best way to reach the product user for behavior change is to start with those who are already open to the idea of the different behavior, but not yet acting on it.

Of behalf of Milieu Centraal, their strategic communication advisor argues that:

"People who say they want to do something but don't do it yet, you get them a lot easier than people who, for example, say they don't want to do something and don't do it yet."

This is how Milieu Centraal finds their target audience. They try, on one side, to change real behavior, but at the same time to be widely visible with their interventions, to get people to start talking about it, as a way to spread awareness. Repair Café, for example, mentioned that there are also people who organize the Repair Cafés who don't really care much about the environment, but care more about doing something for the neighborhood.

2. Business oriented

a. Steps towards circularity: Businesses (and consumers) are realizing the demand for circularity and are taking steps towards it.

The founder of Repair Café said:

> *"We have been approached by a lot of companies lately, because now that the Right to Repair has been established, companies have realized, this is all really going to happen, [and are starting to think of ways] to meet the requirements."*

BSH as another example, has a co-operation agreement with the Kringloop (a Dutch second-hand store). Devices that BSH receives but are still usable are redirected there. They are being repaired and refurbished, along with the certification BSH has in that area, to put devices back on the market. At Repair Café, they advocate that products should be more repairable and that users also have to take responsibility to handle them with more care.

b. Ownership: Consumers and businesses are both starting to move toward rental-lease constructions.

The service manager from BSH said they also have a rental-lease construction under the brand name BlueMovement for their products. This is a construction where products are returned after the lease period ends, which gives the company the opportunity to put the products back on the market or offer it back to new customers, to reuse them. BlueMovement tries to repurpose products that are still valuable and can be used again.

The advantage of the rental-lease construction is that the customer is buying a solution, BSH's service manager argues. The customer buys a washing machine for their laundry that keeps piling up. The moment the machine stops working, you have a problem, again your laundry piles up more and more. With a rental-lease construction, the customer will call BSH, and they can give advice right away. According to BSH's service manager, sharing products and leasing or renting products are becoming more commonplace.

3. Tools and information

a. Awareness and initiative: Product users might not always be aware of the proper ways to perform maintenance activities and will then not take any initiative toward maintenance.

All new appliances come with a user manual. If the appliance requires maintenance, this can be found in the manual. However, in the conversation with BSH's service manager, he mentioned that for them, customers will have questions regarding these instructions in the manual. Based on questions that come in via customer service, they try to make additional videos. BSH is working on communicating what resources are available and what they are there for. One means might be to clean, descaling is another one, or there are means where hygiene is achieved. They do that through all the contact options that are available, like instructional videos and communication via their app.

b. Neutrality: There is a necessity for neutral information, which can be provided through effective communication and collaboration between organizations and businesses.

Most appliances require specific prescribed products like descaling tablets, filter sizes or other cleaning agents. However, there are also other options at hand for maintenance products. BSH argues that coming up with descaling agents yourself, like vinegar, is sometimes not a good thing to do, because vinegar contains certain acids, which in turn can affect the seals. Those acids, for example, are not in the concentration in prescribed descaling agents. BSH's service manager also mentions that a descaling agent from brand X is just as good as brand Y. Labeling it yourself as a company only provides more reliability for the consumer.

Regarding repairment, Repair Café argues that many professional repairmen and also product manufacturers are often very hesitant about DIY repair. The idea they convey is that it is dangerous and that you should not

start opening up the appliances yourself. According to Repair Café, more transparence is better than discouraging all forms of DIY.

3.3 Interpretation

In this section, the findings from the field expert interviews are discussed, how they related to the findings from the context analysis.

Capability - The user needs simple guidance and motivation in order to realize their full potential for DIY maintenance (and repairment). Encouraging a sense of self-sufficiency in consumers through accessible information and the development of a routine could improve their engagement with appliance maintenance. Overcoming initial barriers, such as lack of knowledge or confidence, could support users in taking action.

Reach - The best way to reach the product user for behavior change is to start with those who are already open to the idea of the different behavior, but not yet acting on it. The willingness to adopt a different behavior — in this case, better EEA maintenance — can stem from environmental concerns, but also from other motivations. For a successful communication strategy and ultimately the adoption of desired behaviors, it is therefore relevant to look beyond sustainability motivations and consider the social context in which maintenance behaviors take place.

Steps toward circularity - Businesses (and consumers) are realizing the demand for circularity and are taking steps toward it. There are several steps that businesses can and some are taking, to participate in circularity, including reuse, refurbishment, and recycling.

Ownership – The rental-lease construction changes the incentives for maintenance for the manufacturer. It becomes more favorable for them to encourage proper maintenance.

Awareness and initiative – In congruence with findings from the previous chapter (see paragraph 2.3 Access to maintenance information), it is found that an instruction manual or customer service options provided by the manufacturer require initiative from the user to read or look up. Since additional information to the instruction manual is often necessary, it is the interpretation that there is not a clear medium that ensures that the user will be aware of the proper ways to perform maintenance and to find the proper tools. This will ultimately lead to users not realizing the necessity to perform the maintenance.

Neutrality - It is found to be important that there is open communication from manufacturer to customer about what type of cleaning agents can be used, and for what purpose. Manufacturers create the perception that the user should only use their maintenance products like descaling tablets, which results in a lack of neutral communication. Even if the manufacturer aims to value the safety of the consumer, simply providing the information would be a better approach than discouraging all forms of DIY. The same notion could be applied to 'DIY' maintenance instructions, where more neutral and transparent guidance could empower users rather than discourage them.

MAIN TAKEAWAYS FOR TOOL DEVELOPMENT

1. The tool should function as **a recurring reminder**, as most people are capable of performing maintenance but tend to forget over time and lose awareness of its importance.
2. The tool will focus on changing **the user's perception of their own ability**, which should be overcome by also changing their perception of effort, through explaining **the basic characteristics of maintenance tasks**.
3. The choice is made to focus on individuals who are already **open to the idea of adopting maintenance behavior**. The communication strategy will target motivations beyond sustainability—such as saving money or reducing effort—to encourage the desired maintenance actions.
4. The communication for maintenance will focus on **encouraging motivation**, because rental-lease constructions are shifting the incentive for maintenance away from the product user.
5. The **perception of necessity of maintenance** needs to change, because this plays a role in whether someone will look up information. When someone becomes aware of this, there is a lot of information accessible for someone to take the next steps in performing maintenance.
6. The tool should provide **neutral information**, not influenced by prescriptions from one specific producer.

Chapter 4
Theoretical Framework for Maintenance Behavior

Starting in the exploratory stages, as well as during the later stages of this thesis, a literature study was conducted in order to get a better understanding of the topic of product maintenance behavior and the drivers and barriers for it, especially relating to current behaviors, but also desired sustainable behaviors that an intervention could achieve. From different behavior and motivation models, a combined and integrated theoretical framework was composed. This framework functions as a base for explaining a product user's behavior, with a focus on triggers in relation to motivation for maintenance of electric and electronic appliances. The method for this literature study was done through compiling selective keywords to search in scientific databases and often subsequently by performing the snowballing method. On the other hand, various papers were recommended by supervisors or other experts. A list of how essential literature in this thesis was found is depicted in Appendix D.

Parts of the framework were used throughout all four stages of the double diamond method, but the components of this theoretical framework, along with insights from the context analysis, are mainly used for setting up the interview protocol for the user interviews (see Chapter 5 In-Depth User Perspectives).

There are various different approaches to setting up models for defining behavior. For this research, a focus on motivation was taken as leading for which models to use, with the COM-B model (Michie et al., 2011) as a basis, combined with Fogg's model of behavior (Fogg, 2009), which had been adjusted by Ackermann et al. (2018) in accordance with the context of product maintenance.

This chapter's first paragraph sets up a general model for analyzing behavior, using the COM-B model of behavior and Fogg's model for behavior change. This combined model defines behavior as a consequence of two different sources, namely (1) (cap)ability and opportunity and (2) motivation. In the following two paragraphs, these source categories are each respectively set out using additional analysis of behavioral scientific theory, like the Expectancy Value Theory (Wigfield & Eccles, 2000) and Self-Determination Theory (Ryan & Deci, 2020), concluding with a paragraph on stimuli and triggers.



4.1 A (combined) model for behavior

Behavior can be seen as part of a dynamic system with positive and negative feedback loops, influenced mainly by three factors: capability, opportunity and motivation. These components help to analyze as well as predict someone's behavior, as described by the COM-B model of behavior in Figure 12 (West & Michie, 2020, Michie et al., 2011). This model can provide a framework to 'identify individual, social, and environmental factors enabling and/or preventing [...] [desired behaviors] in young adults' (Willmott et al., 2021). Furthermore, Fogg's behavior model (Fogg, 2009) adjusted for the context of product care by Ackermann et al. (2018) in Figure 13 describes these as factors that influence consumer product care, categorized as either factors of motivation or sources of ability and consequently triggers that influence them (note that here, product care is defined as all activities initiated by the consumer that lead to the extension of a product's lifetime; this research focuses on maintenance, which is only part of that definition). Michie et al. (2011)) splits the sources of ability into two separate components: capability and opportunity. The COM-B model and Fogg's behavioral model can therefore be combined and together can be used for specifying and categorizing elements of both current problematic and desired target behaviors (Gangrade & Khadilkar, 2023).

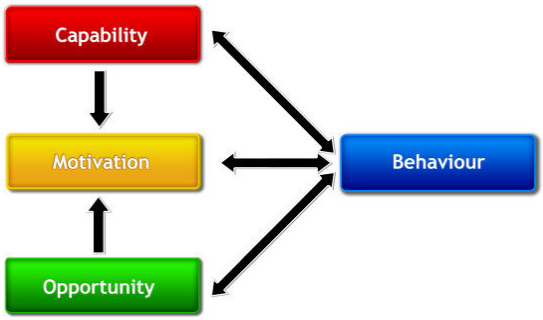


Figure 12 *The COM-B System (West & Michie, 2020)*



Figure 13 *Fogg's model of behavior adjusted by Ackermann et al. (2018)*

In Ackermann's adjusted model, the relation between motivation and ability determines the likelihood of product care behavior, meaning that high motivation can compensate for higher difficulty to take care and lower difficulty to take care can compensate for low motivation. This is in accordance with the COM-B model, where sources of ability are split into capability and opportunity, which both function in relation to motivation, and that relation affecting behavior, also as a dynamic system with positive or negative feedback loops, just like Fogg's model. Examples of what sources of (cap)ability, opportunity, motivation and triggers can be, will be elaborated on in the following paragraphs.

4.2 Sources of cap(ability) and opportunity

Within the COM-B model, opportunity is explained as: 'All the factors that lie outside the individual that make the behavior possible or prompt it (...). With opportunity, we distinguished between physical opportunity afforded by the environment and social opportunity afforded by the cultural milieu that dictates the way that we think about things' (Michie et al., 2011). Capability is described as: 'The individual's psychological and physical capacity to engage in the activity concerned. It includes having the necessary knowledge and skills' (Michie et al., 2011). With Fogg's model, Ackermann et al. (2018) does not distinguish between opportunity and capability, but divides factors of ability for product care in four categories:

- **Knowledge and skills** (capability)
- **Time** (opportunity) **and effort** (capability)
- **Lack of tools** (opportunity)
- **General lack of repairability, or in this case maintainability** (opportunity)

The definitions of capability and opportunity already suggest a connection between them, because for example, having the necessary knowledge and skills (capability) will be highly dependent on whether the physical and social opportunity has been and will be present. It is assumed that if a product owner has never learned the required knowledge and skills for product maintenance from their peers or their environment, they will lack the capability to do so.

Capability and opportunity are not only objective matters of an individual and their environment. There is also the subjective matter of how an individual perceives their capability and opportunity, which Ryan & Deci (2020) describe as competence, which means the 'feeling of mastery, a sense that one can succeed and grow. The need for competence is best satisfied within well-structured environments that afford optimal challenges, positive feedback, and opportunities for growth.' This perception proves the relationship between capability and opportunity and motivation. Lack of tools and a general lack of maintainability do not afford optimal challenges or opportunities for growth.

Time is categorized in physical opportunity afforded to an individual and effort in psychological capacity to engage in the activity. In the context of maintenance time would concern a person's free time that is available for maintenance. This is not something that can (easily) be influenced. However, effort concerns the time that an individual is willing to make for maintenance activities. This directly relates to the concept of intrinsic motivation, which will be discussed in a later paragraph. It is assumed that this factor of effort can be influenced through encouraging people to make plans for periodic maintenance.

4.3 Sources of motivation

'To be motivated means to be moved to do something. A person who feels no impetus or inspiration to act is thus characterized as unmotivated, whereas someone who is energized or activated toward an end is considered motivated.' (Ryan & Deci, 2000)

Ackermann et al. (2018) identified multiple sources of motivation from a user's perspective on product care. Most of these factors are especially relevant to product maintenance:

- **Financial aspects**, when high price of the product has a positive influence maintenance behavior, or the high price of maintenance products has a negative influence
- **Pleasure** that the product brings
- **Functionality** of the product
- **Aesthetics**, when a product looks appealing
- **Intrinsic motivation** for extending the product lifetime
- **Irreplaceability** due to emotional attachment
- **Fit with participant's identity** where the product functions as part of the consumer's lifestyle
- **Shared ownership**, which can lead to feeling less of a responsibility to maintain

In the following paragraphs, these sources of motivation are divided into three different sections using scientific literature to explain them. The three sections consist of the relationship of task value and expectation for success, the concept of intrinsic motivation and the difference between long-term and short-term consequences.

Task value & expectation for success

The expectancy-value theory of achievement motivation by Wigfield & Eccles (2000) describes motivation as a combination of choice and persistence that both influences and is influenced by performance, meaning choice, persistence and performance are a result of 'an individual's beliefs about how well they will do on the activity and the extent to which they value the activity.' For example, if an individual does not belief or expect a maintenance activity to have successful consequences, like improving the functionality or visual improvements on the aesthetics (like a cleaner looking appliance), the chance of them choosing, persisting or performing the behavior is lower. Simultaneously, if the individual does not value maintenance or its results, those chances are also lower.

Components of an individual's value will be either intrinsic or based on interest, utility, attainment or cost (Barron & Hulleman, 2015). Attainment and cost are based on perception. A perceived cost could be the physical or mental amount of effort that it takes, or an actual financial price to pay. In the context of maintenance this could be the price of maintenance products, but also the time that has to be scheduled for the activity. Together, these variables make the following equation:

Task value x **Expectation for success** x **Cost** = **Choice, Persistence and Performance**

Where capability and opportunity are often driven by objectively measurable variables, like the amount of knowledge and information about maintenance, or (lack of) tools accessible, this theory describes motivation with subjectively measurable variables, mostly based on the individual's perception of themselves or their expectations. The expectation for success is a subjective belief based on a task's difficulty. A higher task difficulty impacts behaviors negatively (Ackermann et al., 2018), but before the behavior can even occur, a person's perception of difficulty and effort required will influence their motivation. Self-Determination Theory describes this as the feeling of mastery, being an element of competence as one of the three fundamental needs for motivation (Ryan & Deci, 2020).

Intrinsic Motivation

Intrinsic motivation comes when three fundamental needs are met (see Figure 14), one being competence, which has already been described as strongly related to capability and opportunity, but in the case of motivation, being perceptive.

Another fundamental need is autonomy, which is described by Ryan & Deci (2020) as 'a sense of initiative and ownership in one's actions.' Autonomy is related to the concept of task value described in the previous paragraph, because it is driven by personal interest. Moreover, it is negatively affected by attempts at control from outside sources like punishments, rules or even rewards. An example of low autonomy would be when an appliance sets off an alarm when maintenance is necessary, or even when it is programmed to stop working when maintenance is necessary. An intervention like this could improve someone's maintenance behavior, however it would decrease the motivation for it. This outcome is not desirable, as the user might then be inclined to replace the product with a different one. Autonomy relates to Ackermann's described factors like pleasure and fit with participant's identity.

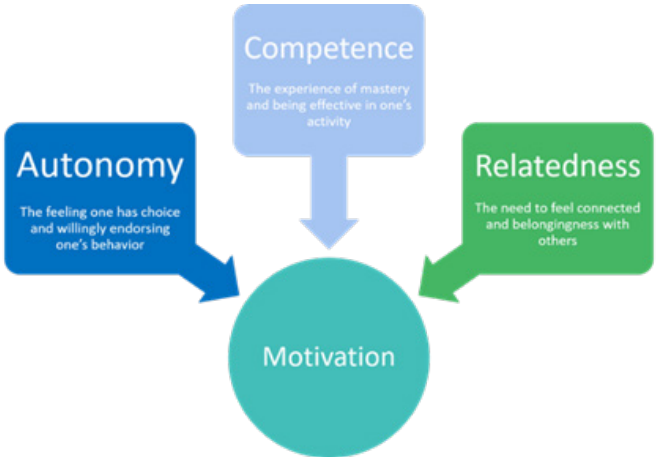


Figure 14 *Fundamental elements of intrinsic motivation (Ryan & Deci, 2020)*

The third fundamental need is relatedness, which is described as 'a sense of belonging and connection (...), facilitated by conveyance of respect and caring,' which explains how shared ownership can lead to feeling less of a responsibility to maintain and intrinsic motivation for extending the product lifetime as well as emotional attachment can have a positive impact (Ackermann et al., 2018).

These three needs will be further explored in the user interviews and in the design specifications. For instance, when it is the case that an individual has high competence and high autonomy in regard to maintenance activities, the intervention would have to focus on improving the relatedness.

Long-term vs. short-term consequences

"At every moment we act in pursuit of what we most want or need at that moment"
(West & Michie, 2020)

Momentary wants and needs are the drivers for people's motivation at the moment when the behavior occurs (West & Michie, 2020). Therefore, it becomes relevant to distinguish between short-term and long-term consequences when discussing where motivation comes from. The concept of temporal myopia further explains this notion of short-term thinking behavior. Uncertainty related to myopia, as described by Van der Wal et al. (2018) is 'the inability to estimate the impact of external, societal events on one's life, and the inability to predict their associated outcomes.' Uncertainty leads to people having myopic tendencies, meaning they will tend to prioritize short-term over long-term consequences. This happens because motivation for adopting new behaviors decreases over time. The longer the time-gap is between a behavior and the positive consequences for it decreases motivation to pursue the new behavior (Herrmann et al., 2020). In relation to EEA maintenance, this becomes crucial to recognize, as maintenance is a preventative measure one takes, in order to avoid long-term negative consequences.

A person's value evaluation can change according to short-term relevance. If values concerning long-term consequences conflict with values concerning momentary wants and needs, they could be neglected, or an 'exception' could be made in order to pursue short-term desires, according to the PRIME theory of motivation (Michie et al., 2011). An example of this regarding maintenance actions would be how the extension of the product lifetime is neglected, when the owner does not bother to read the instruction manual after purchase, because of the momentary want of not liking to read such a booklet. Figure 15 deconstructs this process into the five elements of the theory: planning, evaluation, motive, impulse and concluding in responses (PRIME).

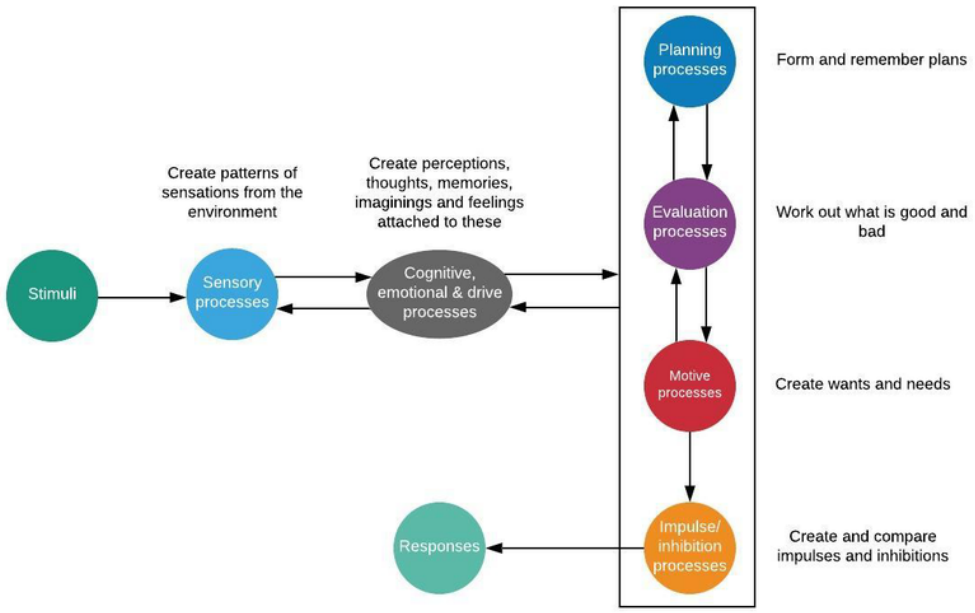


Figure 15 *The process of human motivation according to PRIME Theory (West & Michie, 2020)*

Relatedness, described by the self-determination theory 'concerns a sense of belonging and connection' and is also 'facilitated by conveyance of respect and caring' (Ryan & Deci, 2020). This is higher for short-term consequences, because when either positive consequences (of maintenance) or negative ones (of non-maintenance) take a longer time to be experienced, the sense of the connection between the behavior and the consequences is less clear. This idea is further explored in the next paragraph, as it relates to the trigger Ackermann et al. (2018) describes as previous care activity experiences.

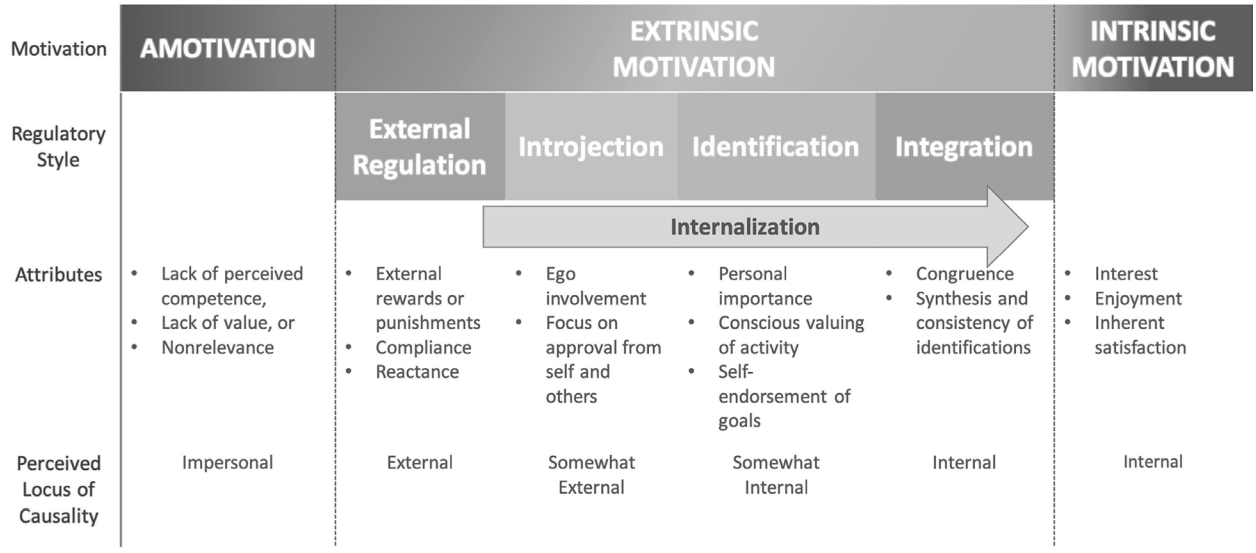
4.4 Stimuli and triggers

According to Fogg's behavior model, triggers can increase or decrease a person's ability and/or motivation, leading toward product care activities. An example of a trigger, also described as a stimulus that provokes someone to perform a behavior (Ackermann et al., 2018), would be when the product does not look nice anymore, or when it doesn't work as well as it is supposed to. PRIME's theory for motivation also describes our actions initially caused by stimuli in our environment and our thoughts (West & Michie, 2020).

Fogg described three ways a trigger can function, namely sparks increasing motivation, facilitators increasing ability, or signals, which function as reminders for individuals that do not necessarily lack either motivation or ability (Ackermann et al., 2018). From this, Ackermann has identified four types of triggers for product care:

- **Appearance triggers**
- **Social triggers**
- **Previous care activity experiences**
- **Challenge-based approach**

An example of an appearance trigger could be an appliance that starts to appear dirty. This could lead to increased motivation to clean as a form of maintenance. Although, whether the motivation is intrinsic or extrinsic, depends on the individual. Intrinsic motivation necessitates inherent interest or enjoyment. Someone might not enjoy the process of cleaning but could only be motivated for the so-called *external reward* of a clean appliance. Self-determination theory describes these reasons or goals as attributes that belong to a *regulatory style* of motivation for a related action (Ryan & Deci, 2000). These attributes and styles are illustrated in Figure 16, which also indicates whether the triggered motivation is intrinsic or extrinsic.



Note. From the Center for Self-Determination Theory © 2017. Reprinted with permission.

Figure 16 *Self-Determination Theory's Taxonomy of Motivation (Ryan & Deci, 2020)*

Chapter 5
In-Depth User Perspectives

The second study was conducted through semi-structured interviews with regular household appliance users, with the aim to obtaining the user's perspective on EEA maintenance behaviors, answering the following research questions:

RQ 2.	**What are triggers that can influence the target product user in their EEA maintenance behaviors?**
SQ a.	What are drivers for maintenance?
SQ b.	What are barriers for maintenance?
SQ c.	How does the user consider and then act upon these drivers and barriers?
SQ d.	Does the user have enough knowledge for proper maintenance?
SQ e.	What is the influence of social environment!

This chapter will first explain the **methods** of how the interviews were prepared, conducted and analyzed. Then, the **interview questions**, divided into 5 topic sections, are explained, including how the theoretical framework for maintenance behavior (from the previous chapter) was applied to the interview protocol. The chapter then goes on to present the **results** from the interviews, using citations from the interview transcripts. The citations in this chapter were selected for explanation purposes. Additional data from the analysis can be found in Appendix C. The chapter then goes on to argue for relevant **interpretations** of the results, in order to answer the research questions and how they relate to the previous context analysis and behavioral literature. The chapter ends by summarizing **main takeaways** for the following steps in the research process.



5.1 Methodology

Participants

In total, 10 participants were interviewed. All but one were either of the age between 26 and 35 or 66+, with the exception being the second participant, who was between 56-65. This means that there were no participants between the ages of 35 to 55. Also, all of the participants have either an HBO or a WO diploma. This was most likely due to the fact that these age categories had been more likely to find time for an interview, because these age groups are most likely either students or retirees and not working a full-time job. These factors will be taken into consideration for the conclusions drawn from the interviews. For a complete overview of the collected personal information, see Appendix C.ii.

There were few restrictions on the types of participants selected for interviews. This was intentional, as the aim was not to conduct a statistical analysis of specific user groups, but rather to carry out an in-depth qualitative study. Therefore, the study did not focus on a narrowly defined user group. However, to minimize potential outliers in behavior and motivation, households with more than three individuals responsible for appliance maintenance were excluded, primarily disqualifying large student houses.

During the interviews, the topic of sustainability came up frequently, mostly by the participants themselves, but also through the closing questions. It happened to be that all participants were either somewhat open to improving their behaviors for sustainability reasons, or very much so. Even though the field expert interviews showed that this should be an intended characteristic of target group, this still needs to be taken into account when interpreting the results and drawing conclusions.

Method of sampling

To find participants, messages were sent out through WhatsApp and via email (see Figure 17, and Appendix C.i for the large sized visuals). In this message, a link to a Google Form, as well as an email address were included. The Google Form only asked whether they were willing to participate in the research, and included a question on how they preferred to be contacted. There were no research related questions or any more personal information necessary for them to provide, because this was supposed to be communicated as soon as either digital or in-person contact was established. Even if they preferred not to fill in the form, they were given the possibility to independently seek contact via email or WhatsApp. This way, anyone that was interested could voluntarily respond to the message, without having to provide more personal information than they were willing to.



Figure 17 *WhatsApp message to acquire participants*

An initial concern with this sampling method was the potential overrepresentation of individuals with technical backgrounds, due to connections with TU Delft, or otherwise participants who were particularly enthusiastic or unusually aware of appliance maintenance. This could lead to a sample group that was more informed and more capable of performing maintenance than the average appliance user. Although most participants did in fact have a technical background or showed a strong interest in sustainable practices, it was still found that many were either unaware of key maintenance tasks or did not carry them out correctly.

Interview preparation

Semi-structured interviews were performed with product users, for in-depth analysis purposes. Characteristics of semi-structured interview are the use of an interview protocol, with generally formulated questions, but also with the possibility to differ from them (Mathijssen, 2024). This method was chosen in order to create an environment for the participant to touch on topics that were not prepared beforehand, but in doing so still keeping to a general structure for questioning, in order to compare answers from different interviews. The interview protocol was set up in congruence with the literature from Chapter 4 Theoretical Framework for Maintenance Behavior and is discussed further on in this paragraph.

Conducting the interviews

After first contact via either email or WhatsApp messaging, appointments were made with the participants. All but participant 8 agreed to have the interview in-person. Most interviews were held at the participant's home, otherwise at another agreed upon location.

At the beginning of each interview, participants were asked to sign an informed consent form (see Appendix C.iii) to ensure ethical compliance. The form provided information about the research, explained how personally identifiable data, such as forms, transcripts, and audio recordings, would be stored in a secure digital Teams environment, and requested permission to use this data anonymously for reporting purposes.

In addition to the informed consent form, the participants were also ask to fill in a personal information form (see Appendix C.iv). This personal information was not meant to be analyzed in combination with the transcript data, but this was meant to determine the suitability of the participant to the target group, and to ensure the validity of the data. If for example, all the participants turned out to be of a specific income class, this would be taken into consideration when analyzing the data. The form did not include their name, email address or any other personally identifiable information, in order to keep this data anonymous. Questions on the form did include their gender, age, education and household situation. In addition there was a question about income status, which was ultimately was marked as optional, after the second interview participant mentioned that he did not want to disclose this.

The first interview was initially prepared as a pilot interview, in order to try out the interview protocol and to acquire feedback on the interview set-up and style. The interview went as prepared and ultimately the transcript was relevant enough to use as part of the research itself.

Interview questions

All interviews were performed in Dutch. The complete interview protocol (in Dutch) can be found in the Appendix C.v. The questions that were prepared are elaborated and argued below, using the relevant literature that they were derived from. The interviews were semi-structured, which means that the questions below were not (always) asked literally or in this specific order but functioned as guidance for the structure of the interviews. Even though the informed consent form mentioned that the interview would be recorded, the participants were also asked in-person whether they agreed to be audio-recorded, to make sure that the participant would be aware of this fact. Following that, the interview questions were divided into six sections:

1. General
2. Experiences and triggers
3. Ability beliefs and motivation
4. Information and tools
5. Usefulness, importance and interest items

Section 1: General

The first section with general questions was set up to get an overall idea of what type of EEA user the participant is, by asking the participant to introduce themselves and asking questions like *'what kind of devices do you own?'* and *'what do you think of when you think of the concept of maintenance of you appliances?'* and also *'what maintenance do you perform?'*. Questions relating to how they perceive maintenance to be important or not and how their identity in relation to the people around them fits in with maintenance behaviors were also asked in this section. The question *'do you ever talk to others about your devices and their maintenance?'* was asked for example, which can indicate whether the participant feels the SDT aspect of 'relatedness' (Ryan & Deci, 2020), being described as a sense of belonging and connection to the behavior and motivation for it. Preceding, the question *'do you experience social pressure or incentive to maintain your devices?'* was asked, relating to the concept of *social opportunity* as part of the COM-B model (Michie et al., 2011).

Section 2: Experiences and triggers

The next questions prepared were about previous experiences and what triggered the participant to carry out maintenance in the past. By first asking '*when was the last time you descaled or cleaned [said device] on your*

own?' and following up with a question '*what was the situation that made you do that?*' the chance was given to the participant to start talking about triggers for maintenance behavior. If the participant could not come up with anything informative, examples of triggers like time, appearance or social triggers (Ackermann et al., 2018), were given, followed by asking whether those examples sound familiar.

Section 3: Ability beliefs and motivation

The next section of questions is about the participant's ability beliefs, meaning how they perceive their own competence. This influences their choice and persistence, and therefore their motivation (Wigfield & Eccles, 2000; Ryan & Deci, 2020). Starting with the question '*do you feel like you are able to maintain your devices yourself?*' as well as having them rate their own ability to maintain their devices on a scale of 1 to 10, gave them the opportunity to explain this. The participants were also asked to describe whether they have habits or customs when it comes to maintenance, which is a part of what the COM-B model describes as *automatic motivation* (Michie et al., 2011). Following questions were about whether the participant ever makes plans for maintenance and whether they remember those plans. The participant was then asked, '*do you ever have other thoughts about your own maintenance behavior?*' in order to have them explain if they ever reflect on the process of making plans and (not) carrying them out. This question relates to the concept of *reflective motivation* and the idea that planning processes and evaluation influence one's motivation processes (West & Michie, 2020).

Section 4: Information and tools

The second and third section focused on the experiences and perception of the participant. This fourth section follows with questions about external factors of information and tools about maintenance. Questions were asked whether the participant has the knowledge and means to perform the proper maintenance tasks and what they do to acquire this. Whether or not the participant has the correct information is an essential part of psychological capability as described in the COM-B model (Michie et al., 2011) as well as Fogg's behavior model (Fogg, 2009) as a factor of ability. Starting with the question *'if you don't know how to maintain your device, what do you do?'* and asking what this experience is like, the EVT concept of *persistence* is explored (Wigfield & Eccles, 2000). Additionally, the participants were asked how they feel about having to look up information with the prepared question *'does it discourage you when you have to look up information?'*, relating to the variable of *time and effort*, which was indicated by Ackermann et al. (2018) as one of the factors of motivation.

Section 5: Usefulness, importance and interest items

The expectancy value theory describes the variables *importance*, *usefulness* and *interest items* as contributing elements for what is explained as *task value* (Wigfield & Eccles, 2000). These variables have a positive relation to motivation. Therefore in this section, the questions *'how important is maintaining [device] to you?,' 'do you find joy in the experience of maintenance of [device]?'* and *'do you feel that maintenance is useful?'* were asked, not specifically relating to any mentioned experience, but in a general sense.

5.2 Data analysis

Each of the interview recordings was transcribed and analyzed by coding them using Atlas.ti. A thematic analysis approach was taken by starting with an inductive coding process. This meant the transcripts were analysed by identifying themes for triggers or factors that contribute to or keep someone from performing maintenance. This resulted in a total of 28 codes. The combined theoretical framework of the COM-B model and Fogg's model for behavior were used to categorize the codes into two sections. This consists of (1) factors of (cap)ability and opportunity and (2) factors of motivation. Within these two categories, several themes were derived. These themes were selected for being most relevant to this research topic. Citations from interviews are presented in paragraph 5.3 Results to describe the essence of each of the themes.

The codes *barriers for maintenance* and *drivers for maintenance* were assigned to citations as well. These two codes were used to find co-occurrence between them and other codes, in order to differentiate between the drivers and barriers of the specified code groups. A overview of the coding data can be found in Appendix C.vi.

Figure 18 shows the complete code tree of the themes derived from the analysis along with their corresponding codes. This coding structure was used to support the presentation and interpretation of the results, which are discussed in the following paragraphs. Table 4 provides a general description of each category and theme within the coding structure.

Categories	Description	Themes	Description
1. Factors of (cap)ability and opportunity	Aspects within the environment of the user or the knowledge that they already possess, that are enabling or disabling the user to perform maintenance.	*a. Instruction manual*	Remarks on the (in)conveniences of the instruction manual and how that affects the participant's behavior.
		b. Types of maintenance products	Insights into how characteristics of maintenance products affect the participant's behaviors.
		c. Knowledge and awareness	The general knowledge participants have about maintenance and how they go about acquiring more knowledge.
		d. Physical barriers	Remarks about (lack of) opportunity in the physical environment that influence a participant's (cap)ability for maintenance behaviors.
		*e. Social interaction**	
2. Factors of motivation	Ideas and experiences that shape motivations for maintenance behavior	*a. Long-term ideas and experiences*	Ideas the participants mentioned about planning maintenance and the experiences with it.
		b. Short-term experiences	The participant's experiences about short-term consequences of (non-)maintenance
		*c. Upbringing**	

Table 4 *User interviews data analysis categorizations and topic selection structure*

***Themes 1e Social interaction and 2c Upbringing left out of the results paragraph and interpretations, due to its lesser relevance to the concluding research goals.**

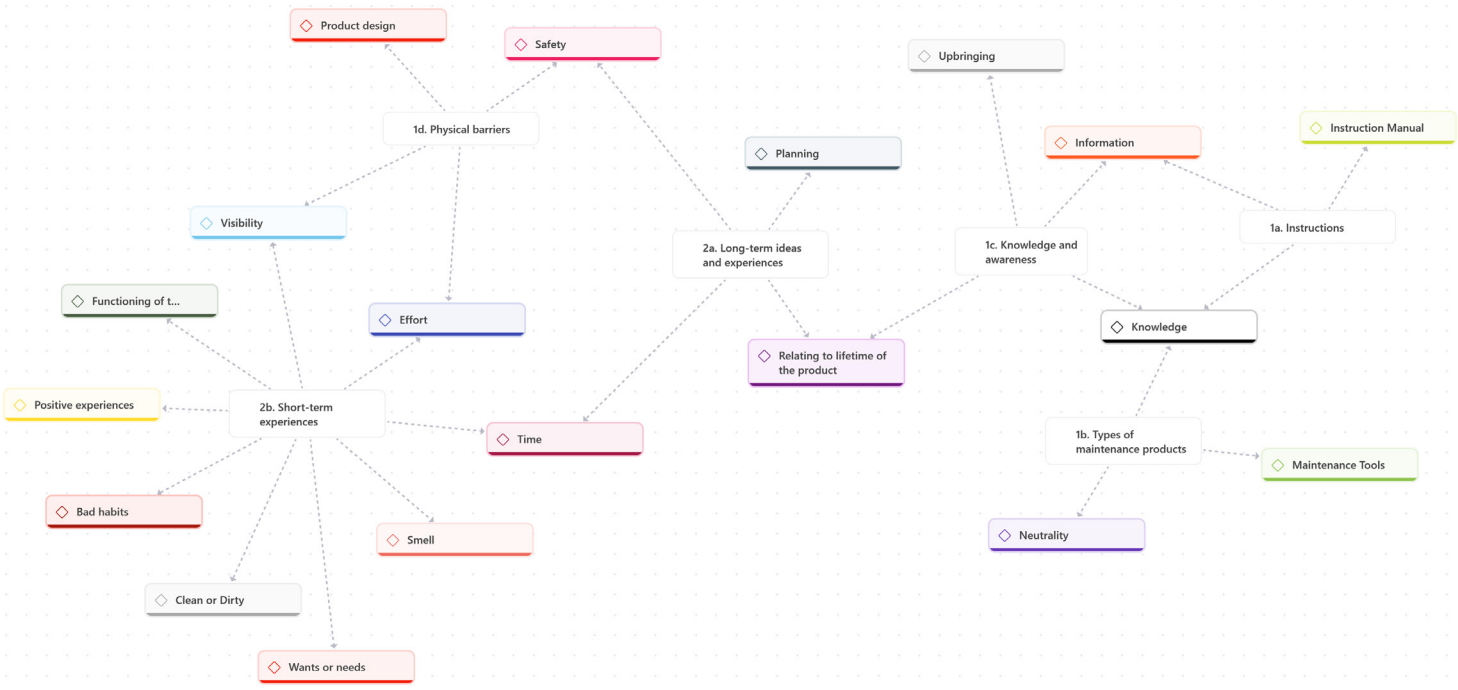


Figure 18 *User interviews data analysis code tree (made in Atlas.ti)*

5.3 Results

This paragraph goes over the most relevant themes from the interview results. Themes belonging to (1) factors of (cap)ability and opportunity were remarks about (a) the instruction manual, (b) types of maintenance product, (c) more general comments relating to the participants' knowledge and awareness, and (d) insights into physical barriers. The most relevant themes belonging to (2) factors of motivation were (a) long-term ideas and experiences and (b) short-term experiences. The results are explained by a limited selection of citations from the interviews.

1. Factors of (cap)ability and opportunity

a. Instruction manual

Participants mentioned frustration with the volume and **complexity** of manuals, which discourages the reading of them. For example, participant 1 said: *"For a lot of things, going over the manual is a step too far,"* suggesting that consulting a manual is often seen as an inconvenient activity. Similarly, participant 3 admitted, *"I'm a bad user manual reader. First, you get four booklets. I know that I can throw away half of it, because they're all other languages. You get an abundance of information. (...) I often find those books so complicated. Too many words."* Participant 8 said *"I browse through it, but I do hate it"* as well as complaining about the number of booklets that make manuals bulky and difficult to find the right information. Participant 5 argued that *"manuals can really be so much better, because they are always gigantic pieces of text, and no one feels like reading them."*

The participants mentioned they will seek **alternative ways** to find solutions for their problems rather than looking for the manual. For example, participant 5 mentioned that *"if I get error messages, I'll Google it - other than that, I really don't use almost any instructions, not even with Ikea cabinets and such,"* and participant 6 mentioned *"the manual usually contains very little information [...] but actually, on the internet you will find much more that you can do,"* indicating a preference for digital access to answers for issues, with a higher chance of finding the information needed. Even participant 4, who described themselves as liking to read instruction manuals, mentioned *"on a dishwasher you have all those error codes [...] in the manual it says that it's a general error with the drain, but then on the internet there is often a very useful tip,"* indicating that additional resources are necessary anyways.

b. Types of maintenance products

The participants also spoke of their confusion about what maintenance product to use. Participant 1 previously had considered using cleaning vinegar but worried it might be too harsh saying: *"I thought, maybe that's a bit intense. I don't know how it affects my device."* Instead, they opted for citric acid, which seemed *"a bit less corrosive."*

For the participants, it takes **directed motivation** to seek out alternative solutions for maintenance products. Participant 1 talked about the **price difference** between generic and branded products: *"[For the] Nespresso with those capsules, I bought those HG things with citric acid solutions. If you actually get those things from Nespresso, I think they are three or four times more expensive."* Participant 8 suggested an alternative and cost-effective maintenance method: *"Something about maintenance, what I read recently, last year or so, is that a combination of vinegar with washing powder ... is very good for the maintenance of your machine, because you actually degrease it again and again."* Similarly, participant 3 emphasized an **environmentally conscious** approach, saying, *"I don't do maintenance with those descaling tablets. I do it with natural vinegar, in the washing machine, as well as my dishwasher,"* also arguing that their product choices are guided by environmental impact: *"My choice always has to do with the fact that they are the least harmful to the environment. I buy a lot of things from Ecover. That is simply a nature-friendly product."*

c. Knowledge and awareness

Most participants talked about their lack of knowledge about the maintenance their household appliances require and how they were not inclined to seek out this information, even though there are instructions accessible. As participant 7 explained, *"Basically, everything I know about maintenance is via-via, or I know because the device doesn't work. And then you get advice, like you can do things like this to prevent that in the future, ... I don't*

proactively look for maintenance." Similarly, participant 4 said, *"I also don't know what kind of maintenance is actually needed on most devices,"* as well as participant 1 mentioning, *"I don't really know how to descale."*

Even when participants are aware of potential issues, like participant 1 mentioning, *"I do know that limescale can accumulate, but I don't have a clear idea if that really makes a difference to the operation of the kettle,"* shows how partial knowledge and uncertainty will keep the participant from taking action. This uncertainty can even lead to the unnecessary replacement or waste of devices, as participant 5 said, *"for me the only thing that broke in our house is the kettle... and we didn't know why,"* suggesting that better awareness of maintenance needs could prevent waste.

d. Physical barriers

When maintenance tasks require physical effort to an extent that becomes too much for the user or when it involves reaching inaccessible areas, the participants mentioned that they are disinclined to perform them. For instance, participant 8 describes the difficulty and amount of effort that it takes to maintain a Quooker, saying *"it's not in a place that is very accessible,"* and further explains the physical effort involved: *"I have a large drawer with four waste bins, and they have to come out. Then I have to dive into that drawer to find out."* Participant 8 had said *"cleaning the fridge, I really don't like that. That's quite a lot of work. You have to plan it. You have to clean those plates, and all the corners and spaces."* These types of physical inconveniences seemingly demotivate people to perform maintenance.

Participant 4 mentioned how *"everything is so densely built up these days that if something goes wrong, you can't reach it anymore,"* later also mentioning that some parts *"can just easily be taken out and put back in again,"* but adding: *"I don't go any further than that. I'm not going to tinker with devices without warranty for fun."* Also, participant 7 said: *"I don't decalcify my Nespresso machine. (...) It is quite a closed system"* and later adding *"the device should kind of show that it can be maintained."* It seems that, even though often times most maintenance should not have to take too much effort, the thought of having to take apart an appliance which is densely built will demotivate people to try to figure out the maintenance that is necessary.

Participant 2 stated *"I'm so tall that I'm right above it, so I don't see it (...) [and] I don't think about it. I'll forget that one."* Indicating that visibility of the appliance can be a barrier for maintenance awareness. Moreover, appearance triggers relating to negative consequences of non-maintenance were mentioned several times. Another example is how participant 3 shared that they *"really do [maintain the kettle] regularly, because I bought a glass one now,"* arguing how the transparent design allows them to *"see it very well in that there is limescale in it."*

2. Factors of motivation

a. Long-term ideas and experiences

The participants generally indicated maintenance of household devices to be a task driven by immediate necessity rather than **long-term planning**. For example, participant 1 stated, *"maintenance is often something I need to do, and then it just has to be done at that time, because otherwise I know it will take another month."* Similarly, Participant 5 mentioned the habit of postponing maintenance activities, saying, *"If I don't have time for it for a day, I'll postpone it or something."*

There were also statements made about whether participants **related maintenance to PLE**. For example, participant 1 said that he knows maintenance extends the product's lifetime, however also saying: *"I think it's a by-product of it. I then think, okay, it's good that all that limescale is gone now, but I think it [the lifespan of the product] is a by-product."* However, the long-lasting of appliances can bring satisfaction, as participant 9 expressed: *"When it [the car] lasts for 25 years, I think it's nice. I don't know why I like that, but yes, it does give satisfaction."*

An aspect of maintenance that participants do associate with long-term benefits is safety. Participant 5, for example, notes that they keep their oven clean *"more for fire hazards than for maintenance, for longevity,"* however still adding to this statement that *"it will probably help in the end, but it's not the direct reason why I'm cleaning it."*

b. Short-term experiences

Participants talked about how they want to perform maintenance, immediately when they notice problems. These are things related to **short-term consequences of non-maintenance**, such as dirt, leakage, unusual noises or inefficient functioning.

Triggers related to the functioning of appliances were mentioned often. Participant 1 explains that *"when I really see a difference in functioning, then I would think, maybe I should clean it now."* Participant 5 noted that if the vacuum's filter is not cleaned, *"you really notice that it can't vacuum as well,"* implying that the necessity of proper functioning is valued by the user. Participant 8 also points out that if the *"dishes are not clean properly,"* she will realize the need for action, while participant 9 remarks that a clogged extractor hood *"smells bad"* and following that with *"at some point you see that it gets dirtier, so then I think yes, that just functions less efficiently,"* indicating the necessity for cleaning.

Similarly, Participant 2 mentions that when the vacuum cleaner starts to smell or loses suction, they *"replace the bag"* and check the filter immediately. Participant 6 also stated, *"if it makes a lot of noise, then something has to be done,"* indicating that a problem becomes urgent when short-term consequences become noticeable and the participants are encouraged by solutions that deliver immediate, tangible improvements.

5.4 Interpretation

In this paragraph, each of the themes is interpreted in relation to the context analysis and the literature from the theoretical framework for maintenance behavior.

1. Factors of capability and opportunity

a. Instruction manual

It was found that the participants avoided having to read instruction manuals that come with appliances. The results indicate that the length, complexity, and the format of traditional instruction booklets make for a lack of motivation to use them for looking up information in general, as well as information specifically about maintenance. This leads to a lack of knowledge, which decreases ability and therefore likelihood of behavior (Ackermann et al., 2018; Fogg, 2009), but also results in a lack of awareness about the simplicity of these tasks. Maintenance tasks will be perceived as more complex and requiring more effort than they actually require, which leads to the perception of high *task difficulty* and therefore a lower *expectation for success* resulting in lower motivation (Wigfield & Eccles, 2000). The results suggest that a more concise, visually oriented approach for providing maintenance instructions would be more accessible and appealing to users.

b. Types of maintenance products

The communication around which maintenance products are reliable is not clear enough, beyond the (often expensive) products prescribed by manufacturers. When manufacturers prescribe their own products, the results indicate that users feel a lack of autonomy, which consequently demotivates them to use those products (Ryan & Deci, 2020). In addition, the results indicate that the higher cost of prescribed products than of alternatives made the participants distrust the information about these tools.

When people are not willing to go for prescribed products, it can take directed motivation, for example based on wanting to use environmentally friendly products (task value), or finding a cheap alternative (cost), for them to look up alternative products to use (Wigfield & Eccles, 2000).

c. Knowledge and awareness

The results indicate a general lack of awareness among users about what maintenance tasks are necessary, how to perform them, and why they are necessary. Many participants did not know the required steps or understand

the consequences of neglecting maintenance. This lack of knowledge can come from a lack of motivation to seek out information, despite its availability, because both learning and performing maintenance are perceived as effortful (Wigfield & Eccles, 2000).

The information available is not being used, arguably because people do not realize what knowledge they are lacking and assume their appliances don't need additional maintenance. When users don't know what knowledge they are lacking, it is unlikely they will recognize the need for action. As knowledge and skills are essential components of capability (Ackermann et al., 2018; Fogg, 2009), its absence limits behavior change. What the results show is that users adopt a reactive approach, looking up information about maintenance only when problems arise. A proactive approach would be able to prevent the issues, coming from awareness of the relation of maintenance to long-term benefits like product lifetime extension. Cost saving or the environmental impact are attributes that should be able to function as a source for intrinsic motivation (Ryan & Deci, 2020).

d. Physical barriers

It was found that not being able see or reach certain spots will prevent users from remembering the necessary maintenance. What happens as a result is that the appliance user will not consciously plan for their maintenance activities, which is essential for momentary motivation (Michie et al., 2011). Simultaneously, when consequences of non-maintenance become visible that maintenance is necessary, people seemed to become motivated to perform maintenance.

The participants mentioned that when it takes more physical effort to perform types of maintenance tasks (not to be confused with when the perception of effort is incongruent with the actual effort), they feel less capable (Ackermann et al., 2018), and they will also be less likely to be motivated for it (Wigfield & Eccles, 2000. This is an element of the physical environment relating to ability, but simultaneously influencing motivation as well.

These findings suggest that physical aspects of the environment can function as a reminder and trigger for action. These are considered appearance triggers (Ackermann et al., 2018). Thus, both physical accessibility and the visibility of maintenance requirements directly impact an individual's ability and willingness to maintain their household appliances.

2. Factors of motivation

a. Long-term ideas and experiences

A source of motivation can be intrinsic motivation for extending the lifetime of the product (Ackermann et al., 2018; Ryan & Deci, 2000). While some participants recognized that maintenance can prolong appliance lifetime, for others this connection was either not made, or it was mentioned not to be the main reason for maintenance. Long-term results, like a washing machine that lasts 20 years, can give satisfaction to users, however, the participants don't usually relate this long-term result to maintenance activities, as it seems that people don't like to make planning schedules. Planning or routine behavior is often rejected due to perceived effort or time constraints (Ackermann et al., 2018).

It is found that the participants tended toward a reactive rather than proactive approach, which can be explained as myopic tendencies. These tendencies are reinforced in situations of higher uncertainty, which is described as the 'inability to estimate [a behavior's] impact […], and the inability to predict their associated outcomes' (Van der Wal et al., 2018). Overcoming this uncertainty could result in a more proactive approach.

One area where long-term thinking is more evident is in safety-related maintenance, which implies that risk aversion may be a more effective motivator than durability alone.

b. Short-term experiences

Physical barriers have already been described as (cap)ability factors in maintenance and how these relate to motivation through visibility and accessibility, both also being short-term experiences. People showed to be triggered by short-term problem identifications (e.g., dirt, lower quality functioning, leakage, noise), and often

encouraged by solutions that have short-term effects (e.g., cleanliness, better taste, back to normal functioning). These short-term problem identifications stem from appearance triggers (Ackermann et al., 2018), and solutions with short-term effects from momentary wants and needs (West & Michie, 2020).

The findings suggest that people are more likely to engage in maintenance when they observe short-term problems and are motivated by the immediate benefits of resolving them, such as cleanliness, better performance, and restored normal function.

MAIN TAKEAWAYS FOR TOOL DEVELOPMENT

1. The tool should aim to **minimize perceived effort** by making maintenance instructions **concise**, **visual**, and easily **accessible**, in contrast to user manuals, which users avoid due to their complexity, length, and excessive information unrelated to maintenance. Participants often overestimated how difficult or time-consuming maintenance would be. **Basic explanation** of how little effort is actually needed can increase confidence and likelihood of action.
2. The tool should aim for being a **neutral** and **reliable** source of maintenance information.
3. The tool should focus on **raising awareness** about necessary maintenance tasks and why they are necessary. Participants often lacked knowledge, neither did they take initiative to seek it out without awareness of their lack of knowledge.
4. **Physical accessibility** as well as **visibility** should be central to the tool, because these elements were found to be essential for maintenance behavior to occur.
5. **Short-term consequences** (e.g., dirt, noise) are able to trigger maintenance behavior, and should therefore be emphasized in the communication of the tool's design.
6. The tool should support quick solutions while also nudging users toward **long-term planning** and **recurring motivation**.
7. Long-term benefits like **durability** and **safety** as emotional payoffs that give **satisfaction**. Though not a primary motivator, participants appreciated durable products or cleaning for safety. This should be used in the tool's messaging to support habit reinforcement.
8. The tool will target users who are **willing but not always aware** or able to **remember** necessary maintenance, enabling them to turn their willingness into action.

Chapter 6
Theoretical Framework for Persuasive Intervention Design

In the second diamond of the design process, the framework was extended for relevance to the design process. The framework used to structure and argue for the design specifications in Chapter 7 Design Scope, from which the creative design process follows in Chapter 8 Tool Development.

In order to change behaviors relating to product maintenance, it should be the goal to design an intervention that will influence either factors of motivation and/or sources of ability (Ackermann et al., 2018). Beliefs and attitudes can influence one's motivation (Barron & Hulleman, 2015; Wigfield & Eccles, 2000) through appropriate communication-based interventions and can therefore accomplish behavior change toward circular behaviors (Reynolds et al., 2024).

In the first paragraph, the paper 'a review of intervention studies aimed at household energy conservation' by Abrahamse et al. (2005) is used to explore intervention strategies. This paper reviews thirty-eight studies within the field of applied social and environmental psychology. It distinguishes different intervention types and categorizes them as either antecedent intervention strategy or consequence strategy. An antecedent intervention is defined by its influence on 'one or more determinants prior to the performance of behavior' and consequent intervention by its influence on 'one or more determinants after the occurrence of a behavior' (Abrahamse et al., 2005). It is relevant to analyze both of these intervention types in relation to the topic of appliance maintenance, because the maintenance behavior has to occur regularly. Determinants for behavior either before or after the behavior are assumed to be equally influential. The chapter concludes with a paragraph on persuasive communication, where examples of communication types are argued in relation to the intervention strategies of the preceding paragraph.



6.1 Antecedent and consequent interventions

There are four antecedent interventions that are considered to positively influence environmental behaviors: commitment, goal setting, information and modelling (Abrahamse et al., 2005).

- **Commitment** would be an expressed promise (either spoken or written) by the user to change their behavior. For example, someone who does not regularly decalcify their washing machine could write down the next time that they have to do it.
- **Goal setting** is about specific goals regarding the desired behavior. This could for example be about the desire for the extension of the product's lifetime or about saving costs.
- **Information** concerns providing either general information about problems that might occur or about measures that can be taken. It was concluded in previous chapters that instruction manuals do not realize this enough. They might contain a lot of information, but it was found that users are not incentivized enough to read and/or remember its contents. Abrahamse et al. (2005) concluded that providing information is 'more effective when used in combination with other interventions.'
- **Modelling** is about communicating examples about specific ideal behaviors. There is generally 'enough' instructional information on maintenance steps accessible online, but it was concluded that this is not sufficient enough, because it takes (too much) extra steps for the product user to search for this content.

Regarding consequence strategies, the paper by Abrahamse et al. (2005) explains they 'are based on the assumption that the presence of positive or negative consequences will influence behavior.' These consequences can be communicated in two ways: feedback and rewards.

- **Feedback**, which gives the consumer information about their use behavior, after it has occurred. This can happen right after, or continuously. Studies have shown that frequent feedback is most effective and often used in combination with goal setting.
- **Rewards,** usually in the form of money and are usually also combined with feedback and/or information.

6.2 Persuasive communication

The communication strategy and tool design should focus on some of the intervention types mentioned in the previous paragraph. As has been mentioned, instruction manuals, but also most other sources for maintenance instructions (like blogs or videos), already provide information about how to perform the maintenance. However, they do not function as persuasive communication or aim to evoke any type of emotional response. They do not include **motivational messaging** of **positive or negative consequences**. The user is not yet actively encouraged to perform maintenance. It has been proven that uncertainty will lead people to behave less sustainably (Van der Wal et al., 2018). The strategy should therefore aim for persuasive communication to decrease uncertainty.

It was found that the participants were either not aware or didn't realize the relevance of both the long-term positive consequences of maintenance (i.e. the extension of the lifetime of a product), and negative consequences of non-maintenance. For example, it was determined that an important trigger is the visibility of a problem, even though most negative consequences are not immediately visible (i.e. the accumulation of limescale in a washing machine). Persuasive communication could be relating the desired target behavior and positive outcomes, not with sustainability values only, but also through other factors like cost or effort. Communicating positive consequences by highlighting the immediate benefits of sustainable behavior (Van der Wal et al., 2018).

Consequence strategies make use of the fact that the presence of positive or negative consequences influence behavior. Negative consequences like feedback that evokes cognitive dissonance could be an effective strategy (Abrahamse et al., 2005). For example, this could be done through exaggerating appearance triggers (Ackermann et al., 2018) like messaging visuals of dirt or an unclean look. This makes use of the theory of fear appeal (Ruiter et al., 2001), which is described as an attempt 'to arouse fear in order to promote precautionary motivation and self-protective action' in the form of persuasive communication. A well-known example of this are cigarette packagings, where scary warnings and rational precautions are depicted on the packaging.

Chapter 7
Design Scope

This chapter outlines the process of defining the design scope, concluding in the formulation of the design goal for tool development. This is the final step before the beginning of the second diamond in the research process. The previous chapters have described various main takeaways for tool development, which are used as a basis for the decisions made at this phase in the process. This chapter begins to address to answer the third research question. Chapter 8 Tool Development further addresses RQ3 by turning the design goal into a final concept.

RQ 3. **What does a tool look like that will trigger the product user to improve their EEA maintenance behaviors?**

To set the design scope, relevant design methods were explored. The chapter begins with an extended description of the **target user**, followed by the **design specification** method from the Delft Design Guide (see Figure 19). This method was used to identify design criteria and corresponding categories, including an explanation of their relevance to the general research scope and their relation to the theoretical frameworks from chapters 4 and 6. The chapter then details the **design requirements selection** that ultimately guided the ideation phase and was used to make decisions toward the final conceptualization phase. The chapter then **concludes** with a clear formulation of the **design goal**.

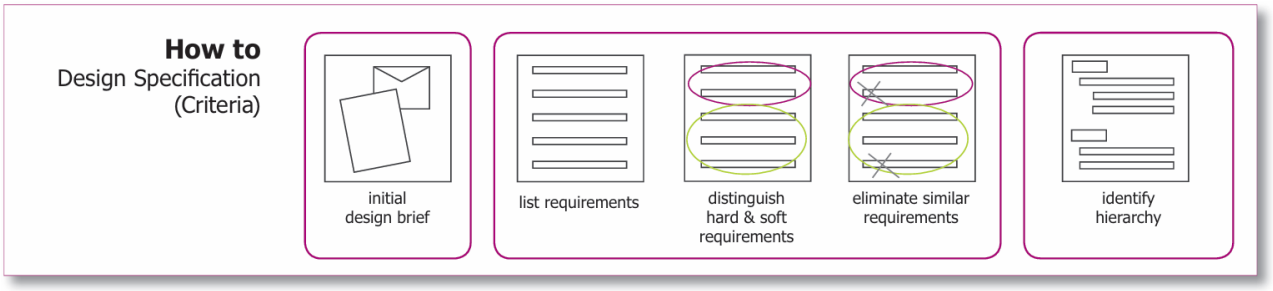
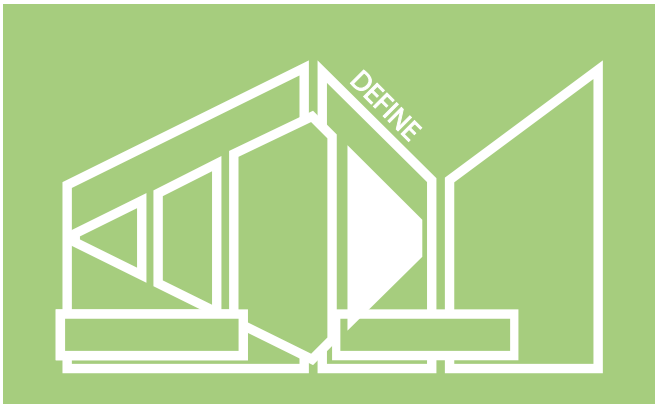


Figure 19 *How to Design Specification (Van Boeijen et al., 2013)*



7.1 Target user

The tool will target individuals across various household types, including those with built-in kitchens. It targets users who are generally open to performing maintenance but may lack awareness, forget tasks, or lack triggers in their physical environment to turn their intentions into action. These users will often value their belongings and, once made aware of it, are expected to recognize the benefits of proper maintenance. However, they are discouraged by the complexity of instruction manuals or the effort required to seek out relevant information. Additionally, the tool will mostly be relevant for people considering the purchase of new household appliances, as it can help establish proactive maintenance habits from the start.



Homeowners or renters across different household types, including built-in kitchen setups



Potential buyers of new household appliances



In need of reminders and simple guidance for maintenance tasks



Willing to maintain when made aware of its necessity



Likely to avoid lengthy or complex instruction manuals



Value an extended product lifetime and caring of their belongings

7.2 Design specification

The design specification method from the Delft Design Guide was followed. A brainstorming approach was used to come up with various requirements within Miro, based on the research takeaways from the previous chapters. This was followed by grouping the requirements into clusters. The Miro board visuals that contributed to this process can be found in Appendix E and depicts a summarization of the list of criteria. In Table 5, all the compiled requirements are depicted. From these requirements, six main ones (marked in bold) were selected. This paragraph follows by arguing for the selection of requirements that is made, from which the design goal was formulated.

Visibility to the user	Other triggers
Motivate to share knowledge with others	
Relating maintenance to functioning of the product	**Informational**
Relating maintenance to lifetime extension	
Provide visual information	
Neutrality & non-bias	
Trigger awareness of the necessary maintenance	
Encourage to make plans for maintenance	**Recurrence**
Encourage long-term commitment to maintenance	
Timeless appearance or satisfactory according to personal preference of the user	
Function as reminder for periodic maintenance	
Trigger fear of negative consequences	**Motivational**
Trigger desire for positive consequences	
Triggering appearance (absurdist, artistic, comical)	
Communicate negative consequences of non-maintenance	
Communicate long-term impact of maintenance	
Evoke positive feelings relating to executing tedious maintenance activities	

Table 5 *List of design criteria and categorizations*

Participant 1 mentioned the following:

> *"Although with manuals I often have [the feeling that] they try to sell you that many capsules on purpose, or just to sell a lot of those kinds of products. So, I only used half of what they prescribed."*

As has been described in the previous chapters, concluded from the interviews, the messaging of retailers and production companies about maintenance activities and tools is unclear. Therefore:

- **The tool must show that it provides neutral (unbiased) information.**

Most participants from the in-depth interviews have mentioned that when they need visual triggers to realize that their appliance needs maintenance. Visibility will trigger the momentary wants and needs that need to be experienced at the moment when the maintenance becomes appropriate (Michie et al., 2011), therefore:

- **The tool must be visible for the user, at least on a regular basis.**

The tool does not have to be a step-by-step guide in how to perform the maintenance activity but should be using persuasive communication to encourage the appropriate behaviors. As described in the problem statement, there is not a lack of available and accessible information. If the user has the awareness of what maintenance is necessary, they rarely seem to have problems finding the proper information. The problem, which the tool will have to try to solve, is that people are not aware of required knowledge, or of the importance of recurring maintenance. According to this quote by participant 7 for example:

> *"It would work if I'd know what a device needs, because I don't know exactly what a device really needs. I only know what I know through other people. It's not like I've read the manual."*

They don't have enough awareness of the importance of going and looking for information by themselves. They either don't know about the long-term impact, or their myopic tendencies (Herrmann et al., 2020) lead them to not think about the long-term consequences. As long as the product works in the moment when they need it to, they are not triggered to enact maintenance. That is why:

- **The tool must trigger awareness about what types of maintenance the product requires, and how often.**
- **The tool must function as a reminder of the periodically recurring maintenance a product asks for.**

Because the tool aims to improve periodically recurring maintenance, as well as having a visible presence in the user's household, it needs to have an aesthetically pleasing element to it. When it becomes part of a well-arranged interior household, that functions as a reminder to the user on a regular basis, it should not become dull over time. Therefore:

- **Either, the tool should have a 'timeless' aesthetic, OR...**

There could also be a choice implemented in the aesthetic design of the tool by making different style variations and consequently giving the user a choice for which style they prefer. By providing this choice, autonomous motivation is more likely to occur as well, while also increasing the likelihood that the user will experience relatedness (Ryan & Deci, 2000) from the communication. This will encourage motivation that is intrinsically driven. Therefore:

- **...the aesthetic should be satisfactory to personal preference of the user (possibly by providing different style variations).**

Maintenance can be viewed as an inconvenient activity. People do not like to do it, or they prioritize other things over it. As participant 7 stated:

> *"I just think it's a bit of a waste of my time to be busy with that. I want it to be clean and that everything works, but I certainly don't want to spend time on it. A device I buy, it just has to work. That's it."*

This relates to the concept of task difficulty described by Barron & Hulleman (2015) and how it influences a person's motivation. It could be the case that some people do take pleasure in these types of activities, but this tool will not specifically target those people. Therefore, it is assumed that the user does not like the idea of having to do it. Similarly, according to the self-determination theory for motivation, the primary need for competence is 'best satisfied within well-structured environments that afford optimal challenges, positive feedback, and opportunities for growth' (Ryan & Deci, 2020). Simply triggering maintenance awareness is therefore not enough, but also:

- **The tool must evoke either positive feelings for maintenance, or negative feelings toward non-maintenance, through persuasive messaging of information, feedback and outcomes.**

It is possible to communicate examples about positive outcomes by communicating immediate benefits of the desired maintenance behaviors, in order to decrease uncertainty, which can lead consumers to improve their behaviors (Van der Wal et al., 2018). Depicting the long-term consequences of (non-)maintenance decreases the time gap there is usually for maintenance behavior and for example the extension of the product lifetime (Herrmann et al., 2020). Therefore, the tool should include only general instructions, but mostly information about problems that might occur or measures that can be taken to achieve positive outcomes, which has proven to be an effective communication strategy (Abrahamse et al., 2005).

7.3 Design requirement selection

The requirements are separated into three groups, which each have each been formulated into a main requirement:

A. The tool must enable the user to get better **informed about maintenance activities**.
B. The tool must enable the user to perform maintenance activities **more often**.
C. The tool must help to **motivate** the user toward performing maintenance task



Figure 20 *Requirement groups for main criteria*

These three formulated criteria encompass all the stated requirements, meaning that the end goal of each of the requirements is to support one of the three criteria.

In order to use these criteria for decision-making, the requirements have been assigned hierarchical value and set into order from most to least important. The most importance was given to 'visibility', because without the tool being visible enough, the other requirements will fall flat. Second important are the 'evocation of positive feelings or desire for maintenance' and 'trigger awareness', because these were often mentioned by the interviewees as lacking. The decision to put 'evocation of positive feelings or desire for maintenance' higher was made because triggering awareness can happen in more ways than just by the communication tool. The assump-

tion is that once the awareness is even slightly triggered, without positive feelings or a desire for maintenance, awareness only will not change behaviors, based on insights from the interview results.

1. The tool must be **visible** for the user, at least on a regular basis.
2. The tool must evoke either **positive feelings** for maintenance, or **negative feelings toward non-maintenance**, through persuasive messaging of information, feedback and/or outcomes
3. The tool must **trigger awareness** about what types of maintenance the product requires, and how often.
4. The tool must **function as a reminder** of the periodically recurring maintenance a product asks for.
5. The tool should have a '**timeless**' aesthetic, **OR** the aesthetic should be satisfactory to **personal preference** of the user (possibly by providing different style variations).
6. The tool must show that it provides **neutral** (unbiased) **information**.

These requirements are used to formulate a design goal in paragraph 7.4 Design goal & vision and to validate the final concept in paragraph 8.7 Validation. They will determine whether the final tool will be able to change the maintenance behaviors of the users of it, because they are based on the literature studies from chapters 4 and 6, the takeaways from chapter 2 and the results from chapters 3 and 5.

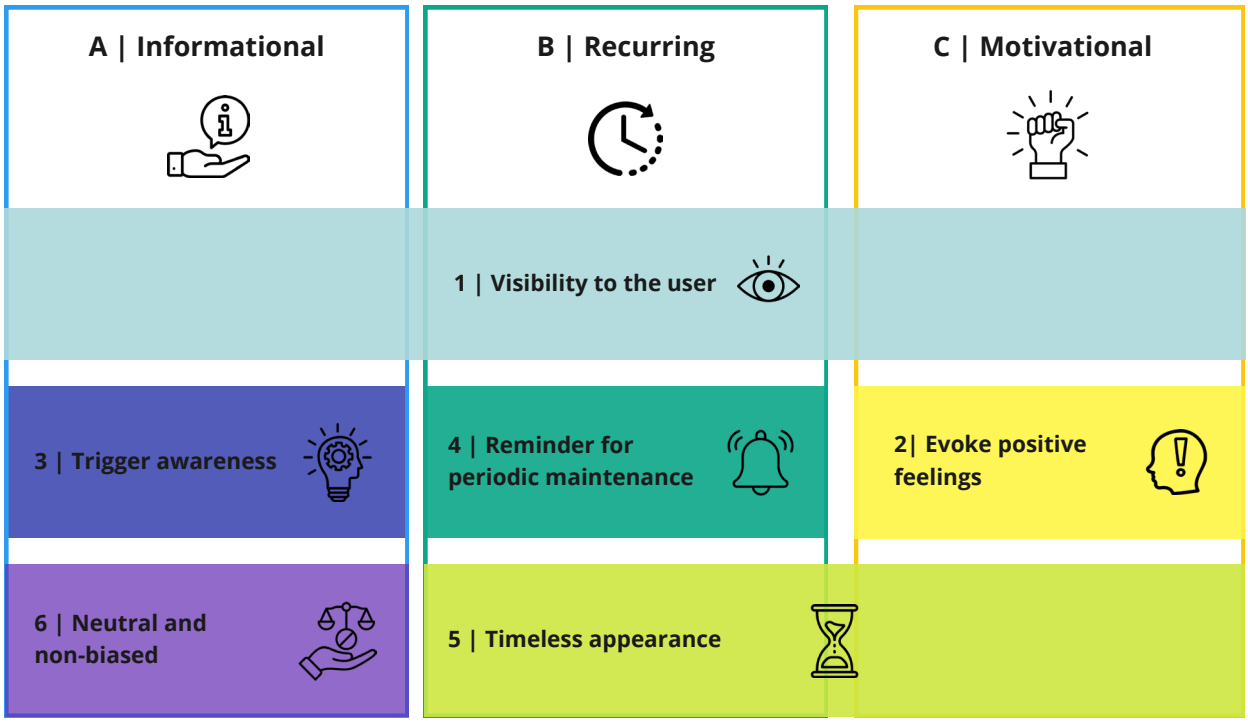


Figure 21 *Visualization of final design criteria including hierarchical value*

7.4 Design goal & vision

In this chapter, a list of design and communication requirements has been identified, based on both user insights and behavioral theory from the earlier chapters, as method to begin to answer the third research question. In order to proceed to the tool development, the design goal and vision are formulated as follows:

Goal:

People that buy a new appliance, or currently own a functioning one, will become more **aware** of what maintenance is necessary for their appliances. They will start valuing the **positive consequences** of maintenance activities over the **negative consequences** of non-maintenance. They will also be reminded of the importance of maintenance on a regular basis by **visible triggers** with a **timeless** or **personal aesthetic**.

The tool design will therefore **inform**, regularly **remind** and **motivate** people to perform the necessary maintenance activities for their electric and electronic household appliances.

Vision:

As a result of people taking **better care** of their electric and electronic household appliances, long-term durable impact will be made when **products last longer**, and E-waste will therefore be reduced.

Chapter 8
Tool Development

'During a design project, even during the conceptual designing stages, new requirements are frequently found because of some new perspective on the design problem'
(Van Boeijen et al., 2013)

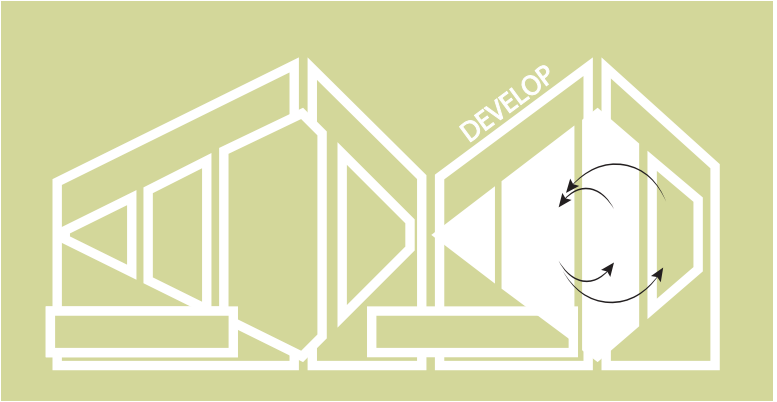
This chapter details the process and decisions involved in developing the final tool concept. The previous chapter began addressing RQ3 by deriving design requirements and a design goal from the research insights and takeaways from a theoretical perspective. The following stage was approaching a practical perspective, by turning the requirements and design goal into concept ideas. Consequently, one concept was selected to effectively address the third research question:

RQ 3. **What does a tool look like that will trigger the product user to improve their EEA maintenance behaviors?**

The next step was validation of the developed concept's effectiveness, with a focus group session and feedback forms, in order to answer the fourth research question:

RQ 4. **In what ways can the tool effectively change the target user's behaviors to maintain their EEA?**

This chapter begins by explaining the **design methods** used throughout the development process. It then presents the results and conclusions from the **ideation sessions**, which led to three initial concept ideas. The following paragraph describes how the requirements informed the **selection** of the final concept. This is followed by an overview of the essential **prototyping** activities that contributed to the final design. Next, the chapter discusses the elements essential for **conceptualizating** the tool's design. In addition to the tool itself, the **final iteration** phase is described, discussing new issues that came up after the main development was completed. It then elaborates on the **validation** activities, including the results and their interpretation.



8.1 Design methods

Design method were used at the different stages of development, based on established practices in the Delft Design Guide (Van Boeijen et al., 2013) and The Product Care Kit (Ackermann, Tuimaka et al., 2021).

- **Ideation - Brainstorming and How-To methods** were used to enable the creative process toward multiple directions, through divergent thinking (Design Council, 2025). The How-To method was used to direct the process toward finding practical solutions for design goal.
- **Concept selection** - the **Harris profile** and **Weighted Objectives Method** were applied to systematically compare ideas using the previously defined design requirements. These methods helped to structure the decision-making process. Through **prototyping** to test materials, sizes and dimensions and applicability validation, an **iterative process** was carried out.
- **Validation** - Three separate activities were conducted: **stakeholders** were consulted, a **focus group session** was held, and **short feedback forms** were distributed. Together, these informed the final iteration, which led to the final design, strategy, and recommendations presented in the next chapter.

The design methods primarily gave structure to the steps taken in the creative design phase. These methods are explained in detail in their corresponding paragraphs that follow in this chapter.

8.2 Ideation

On the 13th of December 2024, a brainstorm session of approximately an hour, was organized with two other students, to come up with different solutions and ideas for the design goal Figure 22 and Figure 23 are photos of the session. One of them was an IDE student and the other both IDE and CDI. A relevant selection of cards from The Product Care Kit (Ackermann, Tuimaka et al., 2021) was used as inspiration for the ideas.



Figure 22 *Product Care Kit used for inspiration during brainstorm session*



Figure 23 *Photo made during the brainstorm session*

Open-ended 'how-to' problem statement sheets that support idea generation (Van Boeijen et al., 2013), based on the design specifications from the previous chapter, were passed around, where the participants could write or draw their ideas (Figure 24). The scans of the sheets are included in Appendix F.ii. Following that, the participants were asked to discuss the relationships between the ideas that were written down. This discussion resulted in design ideas, which consequently were grouped together into different design clusters. Concluding the brainstorm session, 11 design ideas were formulated, based on the ideas written down on the how-to sheets, divided into

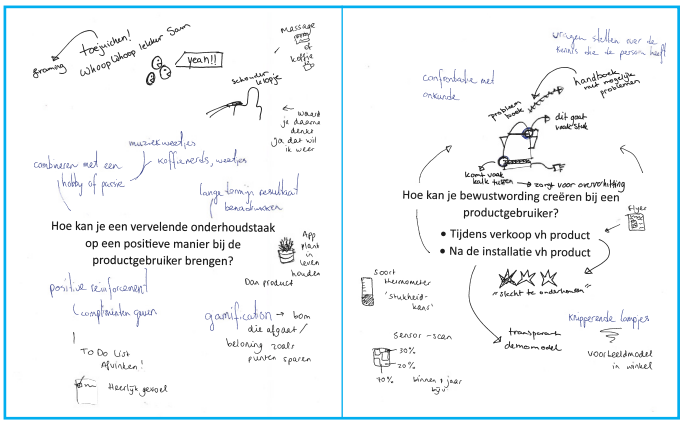


Figure 24 *Two examples of filled in How-To sheets that were passed around during the brainstorm session*

5 design clusters (see Table 6). More details about the set-up of the brainstorm session, scans of the How-To pages and overview of the results can be found in Appendix F.

	Design idea	Brainstorm Idea	Design cluster
1	Changing the design of the appliance with triggers (buzzing, flickering lights, warnings)	*1a, 1b, 1c, 1d, 4e, 4f, 5g*	**Redesign**
2	Transparent casing	*4c, 4g, 5i*	
3	Memory game, connecting negative/positive consequence of (non-) maintenance with the maintenance task that solves/results in it	*2i*	**Gamification**
4	Collecting points system, giving rewards when the proper maintenance is performed	*1f, 3c, 5b*	
5	Magnetic flashcards/stickers to be placed onto the appliance with triggering appearance	*1d, 1e, 2a, 3i, 5a*	**Flashcards**
6	Pocket flashcards with instructions and information	*2e, 5e, 5j*	
7	AI / chatbot for maintenance	*2d, 3h*	**Digital interface**
8	App where the product is personified	*3h, 3i, 3f, 4a*	
9	Calendar planning for your appliance	*2a, 2h, 3d, 3i*	**Planning and reminders**
10	To do list, crossing off tasks	*3d*	
11	Emails, newsletters or phone messages with updates and reminders for maintenance	*2b, 2c*	

Table 6 *Brainstorm ideas, clusters and design ideas*

The cluster 'redesign' was not pursued for further development, due to its lack of feasibility to apply it to existing appliances. This would not accomplish change in the maintenance of appliances that are currently used and therefore cannot be an effective solution. The cluster 'digital interface' is also not further developed. Due to the oversaturation of apps and QR-codes in the current digital landscape, ideas with a focus on non-digital communication are preferred. The three design clusters that will be developed into concepts are therefore:

1. **Planning and reminder**s – A calendar format for your appliance, with the ability to cross off tasks and being reminded for the periodically necessary maintenance

The antecedent intervention of commitment (Abrahamse et al., 2005) is an essential aspect of this concept. The expressed promise is enforced by making the user write down the plan for the next maintenance activity. Moreover, the antecedent intervention of goal setting (Abrahamse et al., 2005), regarding desired maintenance behavior is presented in concept 1.

2. **Flashcards** – Magnetic cards that are placed onto the appliance, with triggering appearance, giving instructions and information about the appliance

This can be considered as the antecedent intervention of information (Abrahamse et al., 2005), because of the general information in the form of simple instructions. By exaggerating appearance triggers (Ackermann et al., 2018) like depictions of visuals of dirt or an unclean look, making use of fear appeal (Ruiter et al., 2001) the effects of consequence strategies would be aimed for. The cards would be magnetic instead of for example in the form of a sticker. The magnetic quality leaves the autonomy (Ryan & Deci, 2000; Ryan & Deci, 2020) to reposition the cards over time.

3. **Gamification** – A memory game, connecting negative/positive consequences of (non-)maintenance with the maintenance task that solves/results in it, possibly including collecting of points and/or giving rewards

Similar to concept 2, concept 4 implements the antecedent intervention of information (Abrahamse et al., 2005), by providing general information about problems that might occur or about measures that can be taken.

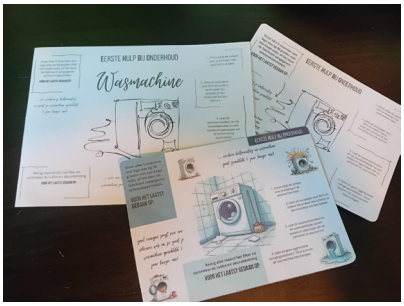
1 | Calendar cards	2 | Magnetic flashcards	3 | Memory game
		
Inspired by:		
		

Table 7 *The three concepts with inspirations*

Some of the concept's visuals were drawn, but others were created using AI image generators. For more detailed reporting on the generators and prompts that were used for the visuals, see Appendix H.

	What	How
1 | Calendar cards	One card per device, as a flipchart system. When the actions have been performed, the card can be turned over and the new card becomes visible.	The intention is that the calendar is given to the customer/user at the time of purchase or instalment. This will have to be placed in a place that is regularly visible.
2 | Magnetic flashcards	Sets of 2-3 cards per appliance, with magnetic properties, which explain the use and maintenance operations that the appliance requires on the one hand, and on the other hand a slightly more artistic visualization of the appliance, so that the look can be chosen to match the interior.	The intention is that the cards are given to the customer/user when purchasing or installing. By means of the magnetic property of the cards, they can be attached to the product itself or another product with a metal housing, as long as they are in a place that is regularly visible.
3 | Memory game	Quartet or Memory game with 4 cards per device, 2 cards per maintenance on one side, device on the other side of the card, with an attached game explanation.	The intention is that the cards are given to the customer/user when purchasing or installing. The cards will have an attractive, playful appearance so that they arouse interest in the customer to play the game. Preference for installations of full kitchen, quartet sets of the following appliances.

Table 8 *Concepts what and how*

8.3 Concept selection

The three concepts were developed into tangible first prototypes, see Table 7, with explanations in Table 8. The concepts are very similar in nature, because they contain mostly similar informational content and similar motivationally driven visuals.

The final concept will not necessarily provide a step-by-step explanation of how to maintain and what is needed for maintenance. The notion is that this information is available and accessible in other places, such as the user manual, online, or via the manufacturer or a neutral party. However, there is still the opportunity to include (a) reference(s) to digital sources.

With this in mind, three concepts were selected for further development to select one for finalization, based on the design requirements from Chapter 7 Design Scope.

Selection based on requirements

A Harris Profile is a tool used to aid the evaluation of concept ideas in the stage where the concepts have not been worked out in detail already, in order to make design choices (Van Boeijen et al., 2013). By ranking the design requirements from 7.3 Design requirement selection, from most to least important and allowing an even number of possible scores to be assigned, the concept ideas can be compared to each other. See Figure 25 for the Harris Profiles of the three concepts.

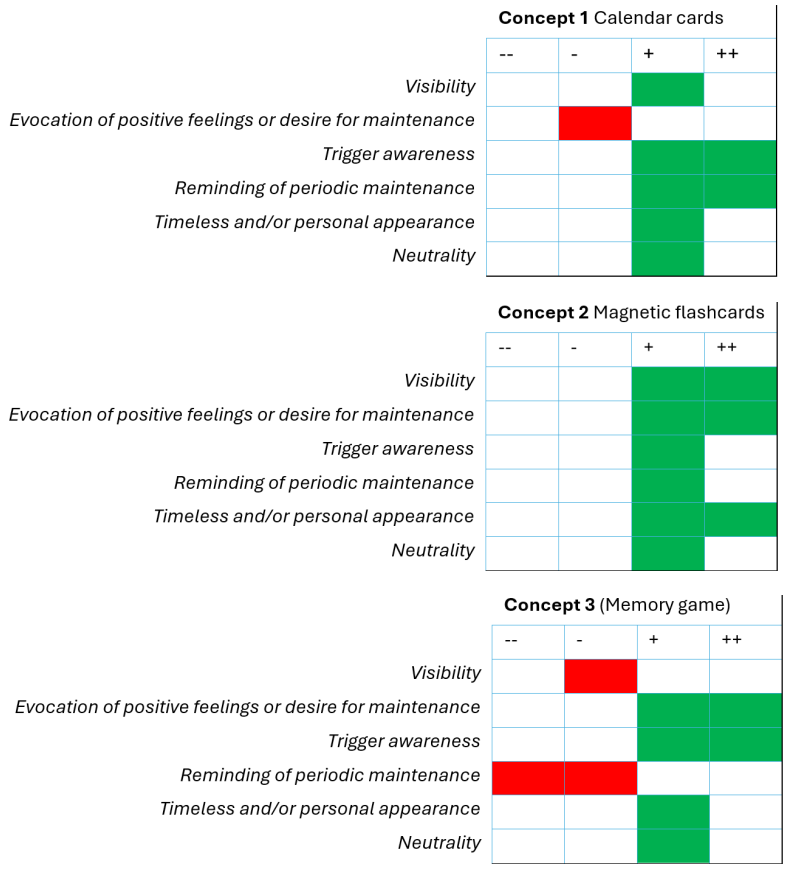


Figure 25 *Harris profiles for the three concepts*

Concept 1 was scored high on 'trigger awareness' and 'reminding of periodic maintenance', because it focuses on making plans and scheduling your maintenance activities. The visibility for this concept would be more unpredictable than the other concepts, because for this concept the visibility depends on whether the user places it somewhere visible. It could be stored in any place chosen by the user. It also scored low on 'evocation of positive feelings or desire for maintenance' because the process of scheduling has been described as unpleasant by the interview participants.

Concept 2 did not score very low on any requirements. It scored high on visibility, because the cards would be attached to the appliance itself and therefore visible every time the appliance is used. It also scored high on 'evocation of positive feelings or desire for maintenance' as well as 'timeless and/or satisfying appearance' due to its possibility for different styles and comical visuals.

Concept 3 was scored low on visibility and also 'reminding of periodic maintenance' because, assuming the game is played after receiving it, it is not to be expected that the owners to keep playing the game regularly. It does score high on 'trigger awareness' due to the interactive element of the game with the maintenance information. From the Harris profile, concept 2 scored the highest. The weighted objectives method was also used on these three concepts. This method is 'best used when a decision has to be made between a selected number of design alternatives, design concepts or principal solutions' (Van Boeijen et al., 2013). With this method, concept 1 scored 755 points, concept 2 scored 855 points, and concept 3 scored 735 points. The complete scoring for each requirement can be found in Appendix G.

In conclusion, concept 2, the magnetic flashcards scored the highest in both of the selection methods and was therefore developed into a finalized design. The development steps are further explained in the following paragraphs.

8.4 Prototyping

Sketching and AI image generation

Sketches were made based on Picasso's one-liner drawings. These sketches led to the first style of flashcards. The sketches are depicted in Figure 29. The other visuals were created using different AI image generators. The steps taken to create the prompts for these images are worked out in detail in Appendix H. The final images are presented in the next paragraph. However, using the image generators came with some issues before sufficient images were created.

Figure 26 portrays some examples of how image generators made mistakes or didn't follow the prompts correctly.

- Figure 26A shows an attempt to generate a Picasso-style image of a washing machine. This attempt failed, as the image generator was not able to create authentic minimalistic, abstract-looking images.
- Figure 26B shows an image of a washing machine in the style of Dutch painter Rembrandt van Rijn, for the target user that prefers an artistic aesthetic. Although the image looked realistic, the decision was made to choose the style of painter Vincent van Gogh.
- Figure 26C shows how the image generator added unwanted elements to the images. The prompt for this image mentioned depicting a dirty oven, with burnt food scraps, however the image generated depicts two whole pizza. This happens with image generators because it bases their images on existing images available online.
- Figure 26D shows a failed attempt to generate an image of a dusty dryer. However, the image generated shows two doors on both sides of the dryer, which is not a correct depiction of the appliance.

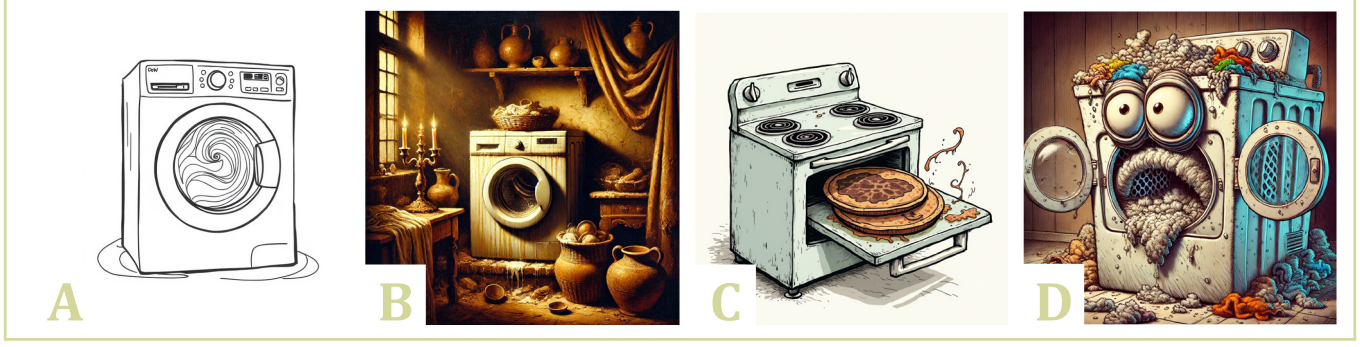


Figure 26 *Examples of failed AI image generation attempts*

Dimension sizes

The dimension sizes for the cards were tested on different types of appliances. Figure 27A, Figure 27B and Figure 27C show examples of sets of three A6 sized sheets (105 x 148 mm) on a washing machine, an oven and a microwave. It was determined that this size would fit, but it was concluded that it was not necessary for the cards to be this big. The decision for a smaller size was based on the preference for the cards to take up less space. Figure 27D shows the different sizes that were prototyped. Ultimately the dimensions of **A7 size (74 x 105 mm)** were chosen for the cards.

Materials

Different materials were prototyped for the cards. The visuals were printed one-sided, and then laminated. Following that, a bendable magnetic strip and double-sided tape was attached in between the front and back side of each card. Figure 27E and Figure 27F show the prototyping of a wooden material. Ultimately, the **flexible magnetic sheet material** was found and chosen for their more comfortable look and feel, as the material in between the laminated card. See Figure 27G, Figure 27H and Figure 27I for what this looks like.



Figure 27 *Prototyping photos*

8.5 Conceptualization

Maintenance information and advice texts

The maintenance blog of BlueMovement (2024) and the AI Chatbot Bram from Witgoed Brigade (2024) were used as sources for maintenance information and advice, which were then formulated onto the flashcards in a concise and appealing manner. In Figure 28, examples of how this was done for the washing machine cards and the oven cards are shown, which can easily be extended to other appliances like a dryer, a coffee machine or a refrigerator. Ultimately as part of the strategy (see Chapter 9 Final Design Presentation & Strategy), the text on these cards could be adjusted according to the preference of the producer or manufacturer that will distribute these cards.



Figure 28 *Examples of information and advice on the backsides of the flashcards*

Images

The choices for the different style variants that were created are further explained later in this paragraph. Three different AI image generators were used for most of the images on the flashcards. Only for the variant 'Abstract & Minimalist' self-made drawings were used. The sketches for is are depicted in Figure 29. The process of creating these AI generated images (see Appendix H) resulted in a final selection of images. The following pages showcase this final selection of AI generated images per variant.

Variants

Different visualization variants for the flashcards are inspired by existing artists or styles. Each style aims to reach the preference of a different target user and suitable for different types of interior designs. In Table 9, each variant's inspiration and target user interest are laid out.

For the first two variants, two different well-known artists were chosen as inspiration, namely Pablo Picasso and Vincent van Gogh. The choice for these artists as inspiration for the visuals is because of the requirement for 'timeless' design. The Dutch Design Awards describe timeless design as time having 'no hold on them, they are inviolable in a changing context' (Berg, 2021). It is assumed that the art from these artists have been appreciated already for a long period, withstanding changes in trends and societal shifts. Therefore, choosing them as inspiration for these variants increases the potential for them to be considered 'timeless' designs.

The drawings for variant 'Abstract & Minimal' were inspired by Picasso's line drawings from the book 'Picasso's One-Liners' (Picasso, 1997). These drawings are considered simplistic but also interesting visually, because of how they are drawn by only using one line per drawing. The minimalistic black and white appearance is less noticeable on a regular washing machine than the other variants. This style was created as a less intrusive addition to the appliance.

The variant 'Strange & Comical' is inspired by the popular card game *Exploding Kittens*, with drawings by Matthew Inman, which is a simple card game with funny and strange visuals that make the game more interesting to play, because each card has a different image of something strange and comical situation. This served as inspiration for the flashcards, because of the triggering but also enjoyable interaction someone could have with looking at the cards. For similar reasoning, the third variant is based on comic book visuals from the so-called *golden age of comic books*, which is the western comic book style that originates from the late 1930s (Robertson, 2017). This style aims to target the preferences of a more youthful audience, due to its playful aesthetic and use of bright colors.

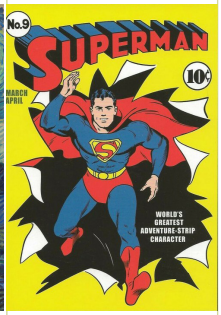
Style	Abstract & Minimal / *Abstract & Minimalistisch*	Artistic & Colorful / *Creatief & Kleurrijk*	Playful & Loud / *Speels & Opvallend*	Strange & Comical / *Vreemd & Komisch*	Cheeky & Extreme / *Brutaal & Extreem*
Inspiration	Pablo Picasso	Vincent van Gogh	Comic book visuals, 'the golden age of comic books'	Visuals from the game *Exploding Kittens*	Absurdism
Target user interest	Modern and minimalist style preference.	Colorful style but not too extravert. Preference for artistic environment.	Youthful, excited	Funny, different, provoking	Over the top, extravert
Example	 *(Picasso, 1997)*	 *(Van Gogh, 1889)*	 *(DC Comics, 1941)*	 *Drawings by Matthew Inman* *(Bordspellenstore, 2024)*	 Prompt: *'A whimsical, absurdist animation-style drawing of a washing machine with exaggerated, comical features (...)'* *AI generated with Dall-E*

Table 9 *Style variants for the concept*

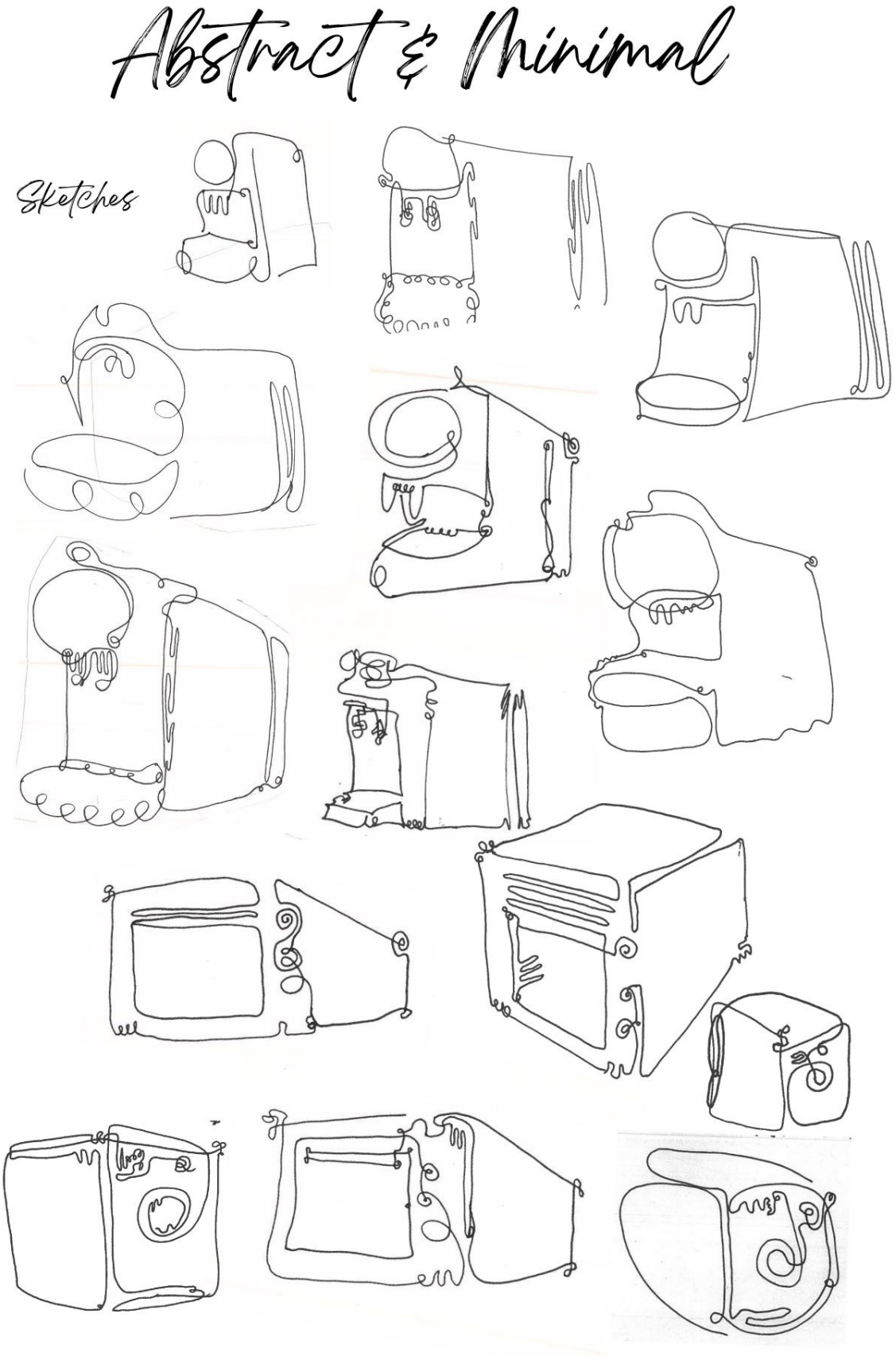


Figure 29 *Sketches for variant 'Abstract & Minimalistic'*

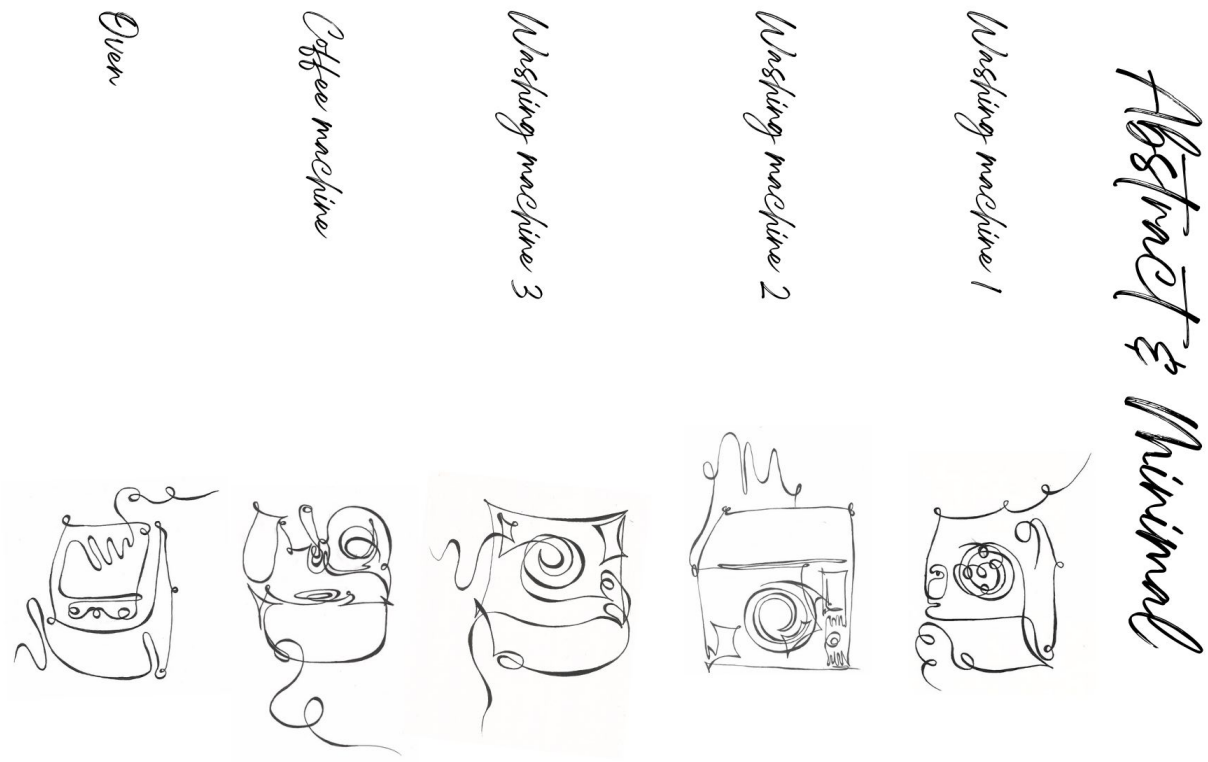


Figure 30 *Visuals for the variant 'Abstract & Minimalistic'*



Figure 31 *Visuals for the variant 'Artistic & Colorful'*

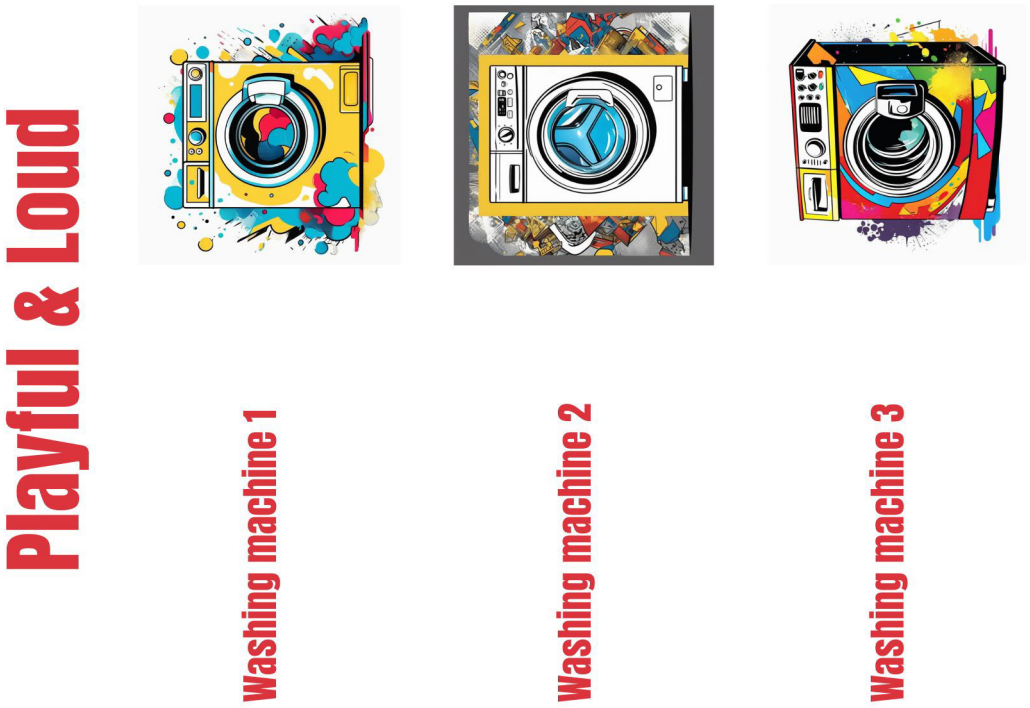


Figure 32 *Visuals for the variant 'Playful & Loud'*

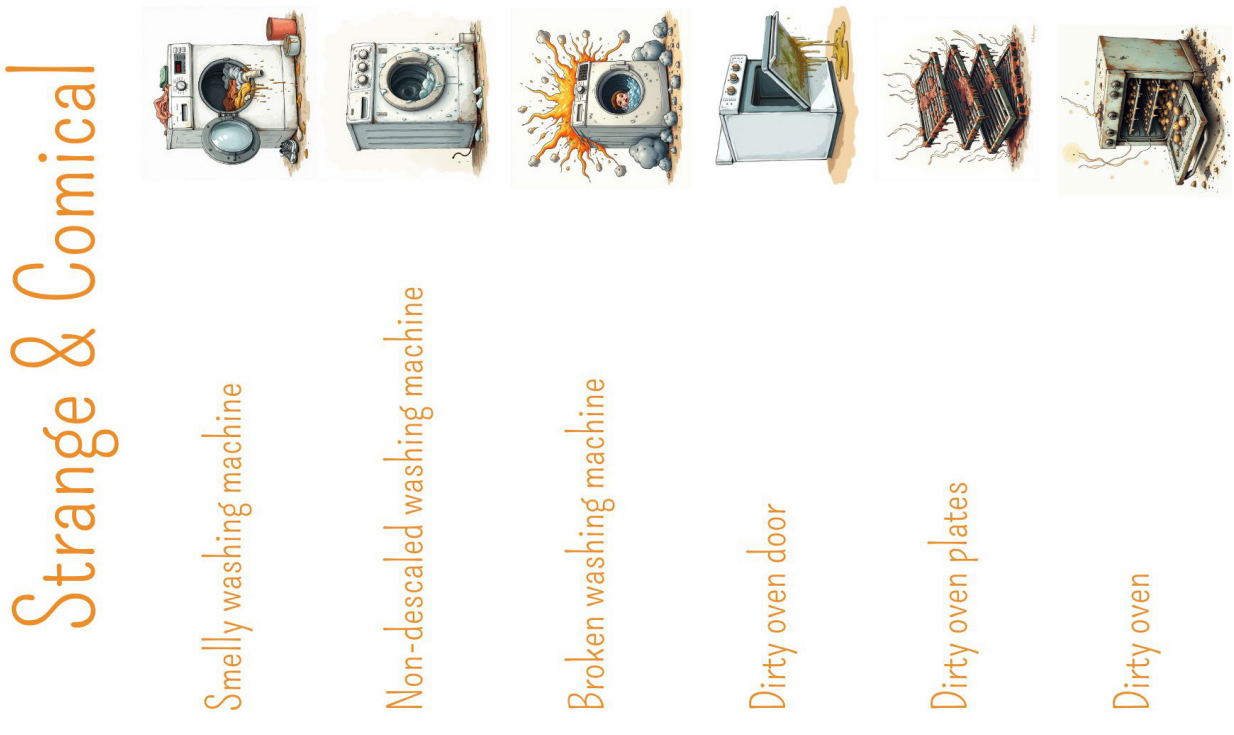


Figure 33 *Visuals for the variant 'Strange & Comical'*

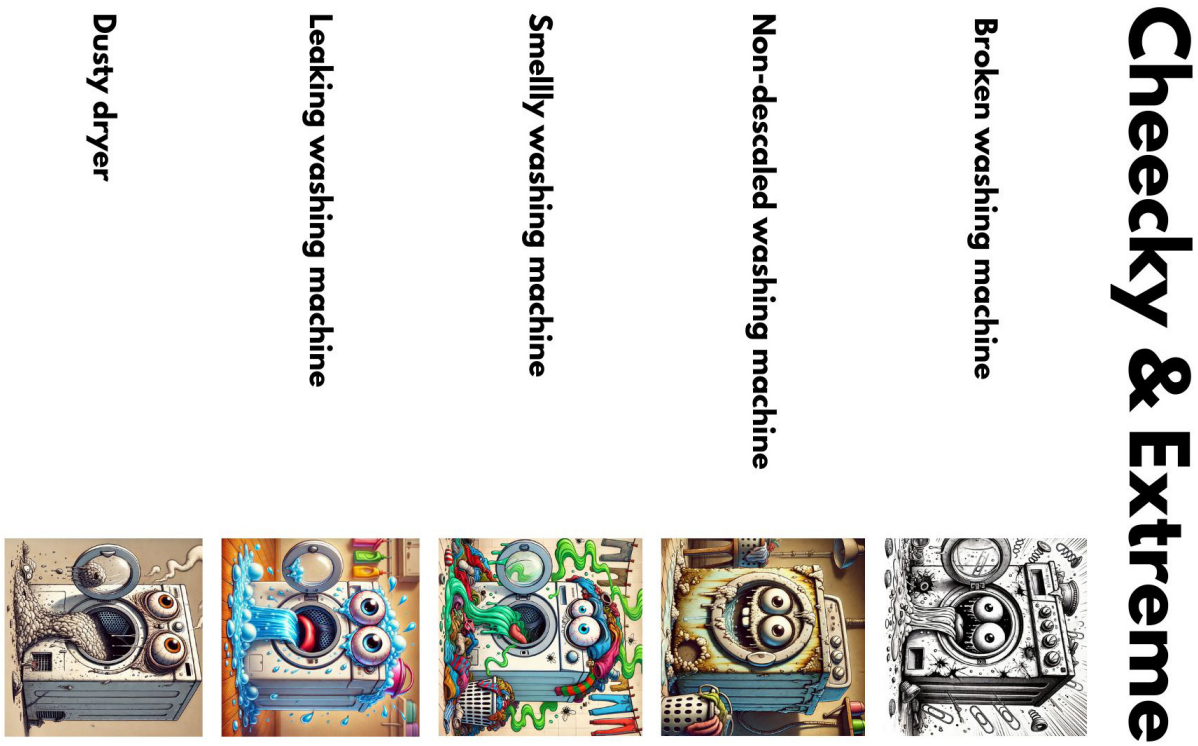


Figure 34 *Visuals for the variant 'Cheecky & Extreme'*



Figure 35 *Card format front cover examples per variant*

8.6 Final iteration

Additional brainstorming

After initial development of the tool, some new issues came up, which led to an additional brainstorm done in Miro. The issues related to the applicability of the tool for people with built-in kitchens, because for those instances the magnetic element is not applicable on any of the appliances in the kitchen. Another issue was the tool still lacking a solution for people who forget the last time they performed the periodic maintenance activity, because the tool focuses on awareness maintenance necessity, not on the planning of coming activities. The additional brainstorming was done in Miro with four How-To questions:

1. *How can you attach a card on another surface?*
2. *How can you make a card visible within a built-in kitchen?*
3. *Where can a magnet be attached (other than on metal appliances) in a regular kitchen?*
4. *How can a card help you plan/remember something?*

The Miro board that was used for the additional brainstorm can be found in Appendix F.iv, including the design ideas that came from it. The ideas that were worked out are explained in the next sections.

Addition 1 - Date for next maintenance activity

To solve the issue of people forgetting when they last performed the necessary maintenance, the idea to make them write the date on the flashcard was implemented. The choice was made to add space for filling out this date. Figure 36 shows how this was visualized for two of the variants. The laminated cover of the cards allow for the user to write on it with whiteboard (non-permanent) marker.



Figure 36 *Addition 1 - Date for next maintenance activity*

Addition 2 - Extra card with QR code to online help

It was concluded that it would be helpful to include a connection to an available online information source, for when the information on the cards themselves does not suffice. Therefore, an extra card was made, including a QR code directed to the chatbot of Witgoed Brigade (see Figure 37). The choice was made to make a separate card for this instead of including the QR code onto the regular cards. The regular cards are intentionally about basic maintenance activities, not about other issues that can come up. The separate card was made in order to avoid a misplaced notion that the maintenance activity might be more complex than the card suggests, as it was found that users perceive maintenance to be more complex than it actually is, and are not aware that they are capable by themselves.

Addition 3 - Installation of RVS plate inside kitchen cabinet

The issue of applicability for built-in kitchens was chosen to be addressed by providing the option to install a metal plate inside the user's kitchen cabinet. Figure 38 shows a render of what this would look like. This option

is ideal for people that are buying a new kitchen, but is also applicable for people that aren't. However, this will come with some extra costs. A custom sized RVS plate, for example 400 X 400 mm, with 1 mm thickness, specifically made for kitchens, costs €39.40 including taxes and can be attached to any surface using mounting kit (rvs-achterwand.nl, n.d.).



Figure 37 *Addition 2 - Extra card with QR code to online help*



Figure 38 *Addition 3 - Installation of RVS plate inside kitchen cabinet*

8.7 Validation

This paragraph lays out the steps that were taken in order to validate the effectiveness of the tool. The goal was to answer the following research question:

RQ 4. **In what ways can the tool effectively change the target user's behaviors to maintain their EEA?**

The design requirements from Chapter 7 Design Scope were used to determine whether the final tool can change the maintenance behaviors of appliance users. For expert validation, a stakeholder discussion was held on the 28th of January at the LLE coalition session. For user validation, a focus group discussion was held with 5 participants, and feedback forms were filled in by a total of 10 people. The validation questions were based on the design goal which was derived from the design requirements.

By questioning the different elements from the design goal toward the different stakeholders (including regular users), it is determined whether the design goal is met in this stage of the design. It is important to note that answers to these questions are all based on the people's perception of the design. Whether the tool could actually achieve behavior change, it has to be validated in practice over a long period of time, because the encouragement of maintenance concerns long-term behavior change. The strategy for this is further explained in Chapter 9 Final Design Presentation & Strategy.

Stakeholders interactive feedback discussion

On the 28th of January 2025 the concept was presented to the maintenance work group of the EEA coalition. Present were representatives of Miele, Applia, New Foresight, Raad Nederlandse Detailhandel, Het Groene Brein the TU Delft. After the concept was explained, a discussion was held about the perspectives that a retailer or a producer might have. Some general insights gathered from the feedback were:

- **The magnetic flashcards could easily become too much 'part of' the machine**
- **Doubts whether the trigger is sufficient**
- **Concerns about fit to personal preferences**

From the retailer's perspective, it was mentioned that they do not want to put time or effort into explaining the tool. The tool should therefore either be self-explanatory or come with something of an explanation that does not need any effort from the retailer. It was noted that it would be relatively easy to hand the tool out for free as a gift.

Speaking for Miele, from the producer's perspective, it was questioned where the money would come from. It was mentioned that it differs per producer whether they would find added value in such a tool. Miele's representative also said: *"If I as a producer would have assurance that the customer wants to attach this to their appliances, then I could be interested."* This indicates that positive validation from the user's perspective could convince producers to implement the tool in their services.

User validation focus group session

On February 6th, a user validation pilot focus group session was held with five alumni/students from the master Communication Design for Innovation. The participants filled out an informed consent form (see Appendix I.iv) and were asked to fill out the first part of the feedback form (see Appendix I.ii), in order to get them to think about what they know about maintenance and what they already do accordingly. Then, they were presented with an explanation of the tool (see Appendix I.iii) and a prototype of the cards. With that, a short focus group session took place, with the following prepared questions:

1. *If you were given these cards, would you want them attached to your appliances? Why (not)?*
2. *Do you think you would remember what is on the back of the cards? Would you take a look at the back of the cards?*
3. *Do you think these cards will help with / improve your maintenance behaviors? Why (not)?*
4. *Take a look at the visuals on the cards. Can you talk about what you see and what you think about it. Do you think the visuals are triggering? What do they trigger for you?*
5. *Take a look at the different styles. Do you have a preference? Why? Do you think there is an additional style that would be a valuable addition?*
6. *Take a look at the text on the cards. Do you think the text is triggering? Do you have any improvements or alternatives?*

The session was recorded and transcribed. The transcription, together with the answers from the feedback forms, was then summarized into positive and negative feedback points to conclude whether can the tool change the target user's behaviors to maintain their EEA (RQ4).

Afterwards, the participants were asked to fill out the second part of the feedback form (see Appendix I.ii), where they were asked to give specific feedback on the tool, whether they would use it and which variant they prefer.

User validation feedback form

Aside from the focus group participants, five more participants were approached to fill in the feedback form. This was done anonymously, aside from age and gender to be filled in. More details on this participants can be found in Appendix I.i. in order to take this distribution into account for the analysis. Participants were informed about the research, they were shown a prototype version of the tool. They were not asked any personal information.

The first question on the form is *'how likely would it be that you would want one of these flashcard sets on your appliance,'* which aims to answer whether the tool's appearance would be satisfactory to the user or even appear timeless 'enough' for them to want it on their appliance. This question also touches on the requirement of visi-

bility, because for the cards to be visible, people necessarily have to be willing to attach the cards to their appliances. The next question on the form is *'which style would you most likely want in your house/on your appliance,'* followed by asking 'why,' in order to acquire feedback on effective qualities of the variants.

The next question on the form is *'do you think you would remember what is on the back of the cards, would you take a look at the back of the cards'*, in order to validate whether the tool can function as a reminder of periodically recurring maintenance and also whether the tool could trigger awareness about what types of maintenance the product requires.

Moreover, the question *'do you think these cards will help with / improve your maintenance behaviors, why (not)'* was asked, because this will determine whether the positive consequences of maintenance will outweigh the negative consequences of non-maintenance, and whether people see any reasons why the tool would be effective or ineffective for behavior improvements.

Finally, the question about any other remarks is asked, in order for people to indicate anything about the tool that could be of value. It should be noted that answers to these questions can only determine people's own perceptions of the effectiveness of the tool on their own behaviors. In order to determine the actual impact that the tool can have on behavior, a long-term test should be performed. This is elaborated on further in the next chapter.

User validation feedback points

1. Placement and visibility of the cards

Some issues came up when questioning the placement of the cards. One participant mentioned, *"I wouldn't necessarily put it in my kitchen."* Another said, *"If I look at my home, I can't hang them in the kitchen, because everything is built-in."* (see paragraph 8.6 Final iteration 'addition 3' for addressing this issue). These responses suggest uncertainty for realizing the intended visibility of the tool. Other participants gave some positive remarks about the visibility aspect of the cards: *"I think it's nice that you can place it near the device itself."* One also noted, *"I also have two daughters, so I immediately start thinking which one does my daughter like. That is why it is also a reason to hang them up visibly."*

2. Information

Participants generally felt they would not consistently remember the content of the magnetic cards without checking the back side once in a while. Some of the feedback about the text was: *"I think I wouldn't remember. I would definitely check out the back."* Another said, *"After some time [I would remember], but the first couple of times I would have to look at the back."* One participant also noted, "*I do think it's good that it [text about longer lifespan] is included. Because when you want a new washing machine it is not really very cheap."* These responses suggest the cards are useful as ongoing triggers rather than one-time information sources, especially for maintenance tasks that are infrequent or periodically required.

3. Triggering appearance

Participants talked about the triggering appearance for motivational factors regarding the cards. One mentioned, *"If you buy a new washing machine once and you see it lasts X years longer, that does trigger me."* Aesthetics also played a role in appeal and placement. One participant noted: *"I think it's personal, but I really like the Strange and Comical. As soon as something is a bit weird, just like the latter, then you have things to look at."* Another said, *"I feel that it [the variant Artistic & Colorful] would go nice with the rest of the room, but having other options is also cool."* Overall, participants reacted positively to the appearances of the variants, noting that the appearance contributes to trigger maintenance.

4. Improving behavior

Generally, participants responded positively on whether they perceived the tool to be able to improve their maintenance behaviors, though the degree of impact differed from person to person. One participant said, *"It's a really nice idea, it would remind me to take care of things I usually forget, because they are needed once every few months,"* indicating that the cards could help address tasks that are easy to overlook. Another response came from someone who said, *"Yeah, I think so, the maintenance will improve. Because we don't clean it right now,"* suggesting the tool could lead to meaningful behavior change. Another person gave the feedback that they expected not too much impact, however , about whether the tool would change their behavior, saying: *"Maybe a little, I don't think the urge gets bigger, but the cleaning itself gets better."*

These results suggest that for some people, the tool could lead to improvement in how tasks are done, even if motivation stays the same. These responses suggest that an essential value lies in the tool's ability to act as a recurring trigger and reminder for the necessary maintenance behaviors.

Chapter 9
Final Design Presentation & Strategy

This chapter presents the final design proposal, as well as the strategy to effectively implement the tool. Firstly, the magnetic flashcards are presented, providing explanation for all its elements, including how people will properly be able to understand how it functions, what people can do when the tool's information doesn't suffice, and some additional information about what can be done for households that have built-in appliances. Next, the long-term strategy is explained in six steps and portrayed in a timeline. The chapter concludes with the final tool presentation poster.

9.1 Magnetic flashcard elements

The magnetic flashcards come in sets of three. The complete collection of all the developed cards, front and back sides, are depicted in the final to last page of the appendices of this thesis report. For this final design presentation, six essential elements of the flashcard tool are depicted in Figure 39, and are explained as follows:

1. Simple and concise instructional information

Each card contains simple instructions about a maintenance activity required for the appliance. This information should be sufficient for anyone to have the confidence to perform those steps. In addition to the instructions, an encouraging detail about a positive consequence of the maintenance is also formulated, generally about the long-term effect of proper maintenance.

2. Bendable magnetic, laminated material

The cards are made up of plastic laminated front and back cover, with a bendable magnetic material in between. This makes the cards easy to hold and comfortably place on any metal surface.

3. Triggering visual about maintenance neglect

On the front side of the card, an image (or text) about a negative consequence of non-maintenance is depicted. This is meant to trigger awareness about maintenance to the user, every time the card appears in daily life.

4. Timer option to write your next maintenance date

The front side also offers the option to write with (non-permanent) marker the date that you plan to do maintenance activity, corresponding with the instructions on the back side. By doing this, the user will take on the commitment for themselves, to keep to the prescribed recurrence of the maintenance, and will be remembered of that commitment, every time the card is seen in daily life.

5. Variant options for personal aesthetic preference

The cards should be attached onto the corresponding appliance, or any metal surface within the household that is regularly visible. This means that the card becomes part of the household interior. In order for the cards to be aesthetically pleasing to the personal preference within the household, there are five aesthetic variants to choose from, each conforming to a different type of targetted user.

6. General card for additional information source

Aside from the set of cards for the corresponding appliance, the customer also receives one general card. This card also contains a QR code that redirects to Chatbot Bram by Witgoed Brigade, who can help with any problems regarding the appliance that remain unsolved.

Figure 40 shows visual examples of the magnetic cards within the intended context *(please note that the prototype in these photos are an older version of the cards. The last iteration was not yet added in this version)*.

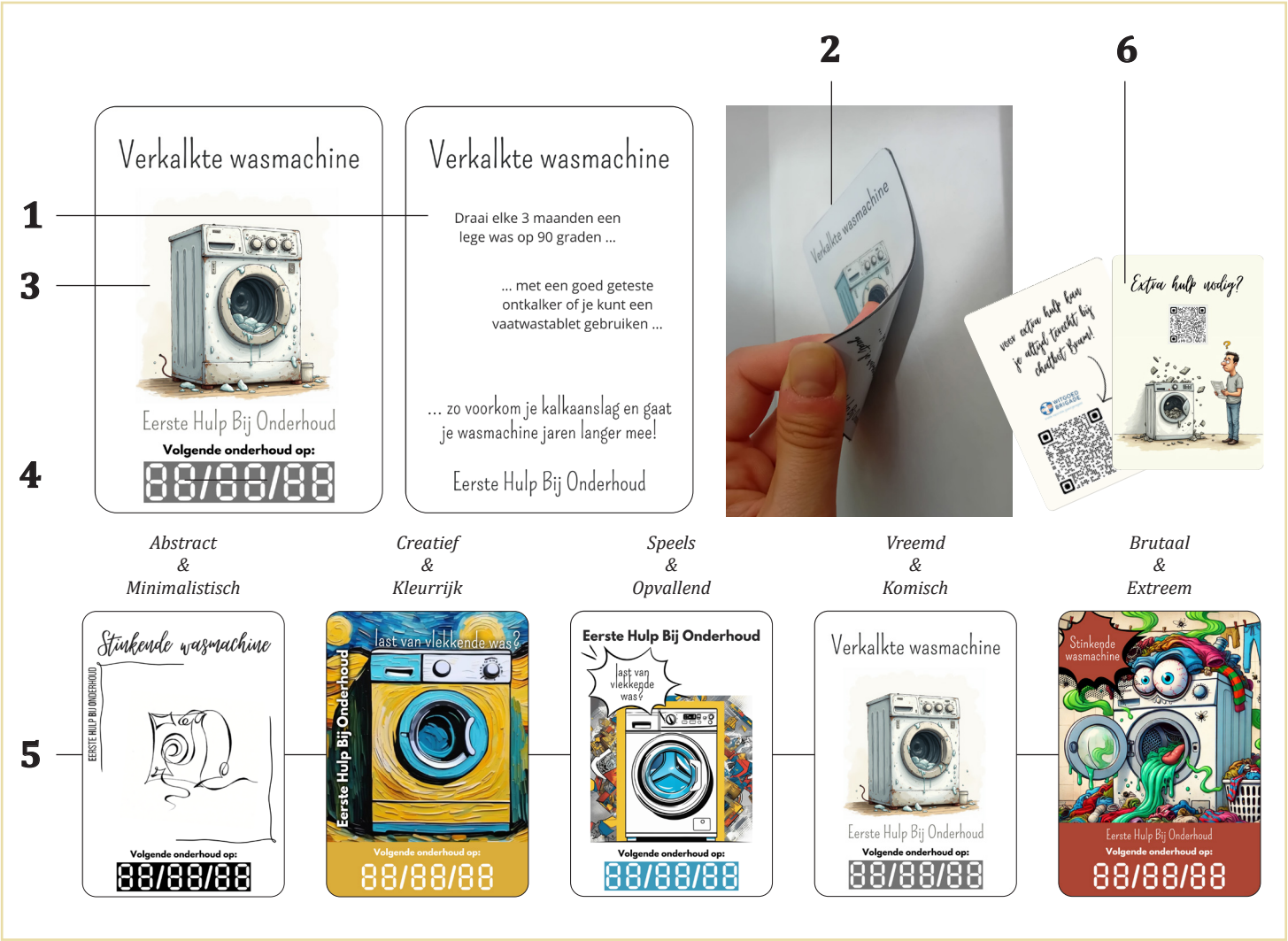


Figure 39 *Depiction of each element of the tool*



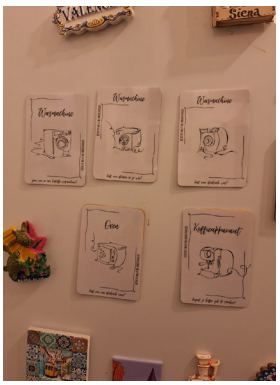


Figure 40 *Photos of examples of the cards in their intended context*



Figure 41 *Optional installation of metal plate inside kitchen cabinet*

9.2 Long-term strategy

In this paragraph, the strategy is formulated by setting out steps for a timeline. These steps are followed by argumentation as well as ways of pursuing them. The steps are as follows:

STEP 1 | Collaboration

The ERSPR requires businesses to shift toward circularity 'from the processing of primary toward secondary raw materials and from production of products to maintenance, re-use, refurbishment, repair and second-hand sales' (European Commission, 2022), meaning that businesses will have to invest in circular economy strategy and practices like repairment, maintenance and refurbishment. The founder of Repair Café said *'now that the Right to Repair has been established, companies have realized, this is all really going to happen, [and are starting to think of ways] to meet the requirements.'* Based on this knowledge, the first step of starting a collaboration should be pursued. A collaboration partner could for example be Witgoed Brigade.

As part of the first step, partnership with Tappr, the platform and **DPP** developer that aids companies in generating GS1 digital IDs for products and enables them to be linked, among other things, to QR codes (UseTappr, n.d.) will be introduced. This partnership allows for the magnetic cards to include the DPP, which functions as incentive for manufacturers and producers to participate in the implementation of the tool.



Figure 42 *Informational postcard distributed along with the tool*

STEP 2 | Distribution

The first batch of ditribution of the magnetic flashcards would be as pilot, to a limited, but significant amount of participants from different target groups, willing to participate in the pilot and provide long-term feedback in the next step of the long-term strategy. Ultimately, the tool would be distributed at any the contact moment of retailer or producer with the customer. This could be when an employee goes on a repair visit or installation job, or the tool could be distributed by retailers in stores, or in public spaces like Repair Café's.

At each individual moment of distribution, either by a retailer, installer, repairman, or whoever is participating in the distribution, the tool will come with an postcard-like information card, see Figure 42. The card consists of an explanation of how the tool functions, and displays the different variants of which the customer can choose from. This will lower the threshold for retailers or businesses to participate in the distribution, because no extra effort or explaining will be necessary. The customer can choose which style variant they prefer based on their depiction on this information card, and they can keep it to have the additional information at hand.

The option to install a RVS plate within households with built-in kitchens will be provided as well (see Figure 41).

STEP 3 | Feedback

Approximately 1 year later, there will be a check in with customers to acquire feedback about effectiveness of the tool, whether it has improved the user's behavior and to collect insight in order to adjust the design of the cards in the next step.

STEP 4 | Improvement

After the feedback phase, the cards should be improved based on this feedback, For example, the text could be adjusted to any new maintenance problems that might have occurred after that time, or adjusted to any developments in the designs of new products on the market. These improvements can then be tested through methods similar to the ones of this thesis research.

STEP 5 | Extension

When the tool is fully developed and validated for long-term effectiveness, the cards will extend to all possible EEA, which each should also be tested for at least a short period of time before step 6 can happen.

STEP 6 | Scale-up

If the success of the tool is proven within the partnerships that were made in step 1, the goal will be to extend collaboration with other stakeholders from LLE Coalition and further.

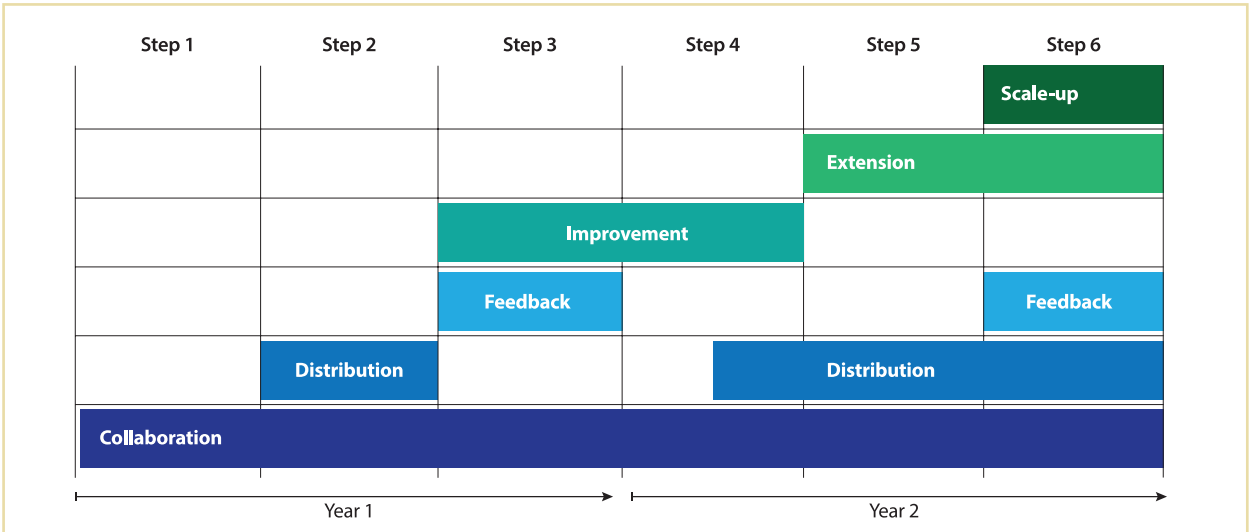


Figure 43 *Strategy timeline*

9.3 Final presentation poster

The Magnetic Flashcards are sets of 1-3 cards per electronic household appliance that help its users **value**, **understand** and **remember** the maintenance that their appliance requires. They ought to be attached to the appliance itself or to any other metal surface in a place that is regularly visible. Resulting from behavioral research insights, they aim to motivate and enhance the ability to maintain household appliances, which will ultimately improve and extend the product's lifetime.

1. **Abstract & Minimal**
2. **Artistic & Colorful**
3. **Playful & Loud**
4. **Strange & Comical**
5. **Cheeky & Extreme**



Different style variants, according to different personal preferences, for different types of household aesthetics

EERSTE HULP



Triggering visuals and texts

Timer for planning your next maintenance task

Simple but useful information and advice about maintenance activities

Motivational text about positive consequences

Bij Onderhoud



Comfortably bendable and laminated material



Magnetic property, therefore attachable to any appliance with a metal housing, for recurring visibility



For multiple different types of household appliances

Chapter 10
Conclusion

The research aimed to explore, analyze and improve the manner in which EEA users behave around their appliances. This was structured by formulating a main research question, and following that, formulating four research questions that, following a chronological structure of subsequently four phases, would answer the main research question.

This chapter first goes to answer each of the four research questions. RQ1 is answered through describing conclusions drawn from the **context analysis** and the **field expert interviews**, about the context around maintenance activities. Next, RQ2 is answered by explaining the **triggers and barriers for maintenance of EEA** that were identified as a result of the in-depth user interviews. The following paragraph answers RQ3, by describing the **design specifications** that were based on the literature and the findings from the research, which led to the **development** of the tool, concluded in a final concept design. The next paragraph goes over the conclusions that were drawn from the validation methods, in order to assess to what extent the tool is **perceived to effectively change behaviors**. The chapter then concludes with the final paragraph, where the **main research** question is answered.

10.1 Context around maintenance activities

RQ 1. **What is the current situation for product users, manufacturers and other organizations when it comes to maintenance of EEA?**

Businesses and organizations

It is found that EU regulations are enforcing businesses to shift from the linear economy towards circular economy business models. This provides the opportunity for collaboration between businesses and organizations aiming to encourage the consumers to shift towards circular action as well. The EEA coalition was founded to speed up the transition to a circular economy by having companies, organizations and institutions collaborate to achieve their goals. The goal to optimize the use of EEA is part of their agenda, which includes encouraging maintenance.

Encouraging maintenance happens in practice on different levels of society. There are companies that follow the pay-per-use model, which shifts the ownership from the user to the supplier, which also increases the incentive for maintenance for companies. However, this could also result in a decrease of incentive for maintenance for the user. The Repair Café has also been successful in not only encouraging but also assisting with product care, and its success illustrates the necessity for preventative measures, like improving EEA maintenance. This indicates the opportunity for encouraging maintenance, in addition to offering help with repairment.

The PaaS business model increases incentives for the companies, but could also decrease incentives for customers, which could have a negative influence on maintenance behaviors. This implicates a necessity for encouragement of maintenance behaviors.

From a business-oriented view, following the 'Right to Repair', companies are realizing the necessity for circularity in their business constructions. They are beginning to adopt practices such as reuse, refurbishment, and recycling. Rental-lease models are becoming more common, shifting the focus from product ownership to service-based solutions, which incentivizes businesses to encourage better maintenance practices.

Encouraging maintenance happens in practice on different levels of society. There are companies that follow the pay-per-use model, which shifts the ownership from the user to the supplier, which also increases the incentive for maintenance for companies. The Repair Café has also been successful in not only encouraging but also assisting with product care.

Accessibility of tools and information

There are various different types of sources accessible for users to acquire maintenance information. There is the instruction manual that comes with any new product. This is usually also provided digitally. There are apps provided by manufacturers, online blogs, chatbots or customer services, instructional videos, and also in-person communication can be a source for information to people.

A problem that comes with the accessible sources, is that it takes awareness of one's own lack of knowledge, and following that it takes initiative to seek out these sources. Without this, the user will not be inclined to take initiative.

User willingness and awareness toward perception and initiative

Individuals who are already open to changing their behavior but have not yet taken action are most likely to change in order to improve their maintenance activities. In terms of tools and information, it is found that maintenance tools and information is generally available, however consumers are usually not aware of the necessary practices or the proper resources accessible.

It is found that people are often more capable of maintaining and repairing their appliances than they perceive themselves to be. Providing clear, accessible guidance and encouraging development of maintenance routines can encourage them to perform better maintenance.

As was mentioned in the previous section, the information that is accessible requires some form of initiative from the consumer. There are opportunities for improvement through better communication, particularly in providing neutral, reliable information about maintenance methods and necessary products for maintenance. Collaboration between manufacturers, independent or neutral organizations, and repair initiatives can help build awareness and especially reliable information for the consumer.

10.2 Triggers and barriers for maintenance of EEA

RQ 2. **What are triggers that can influence the product user in their EEA maintenance behaviors?**

Participants dislike reading the instruction manual due to the length, complexity, and the format, which results in a lack of motivation to use them for looking up information in general, as well as information specifically about maintenance. This leads to a lack of knowledge, which decreases ability and therefore likelihood of behavior. There is also a lack of clarity regarding reliability and neutrality of communication surrounding maintenance products, with participants being motivated to use alternatives, also motivated by saving cost. An overall lack of awareness plays a significant role in maintenance behaviors. Many participants were unaware of necessary maintenance tasks and did not actively seek this information, leading to a reactive rather than proactive approach to maintenance.

Physical barriers, such as inaccessible components or tasks requiring significant effort retain users from maintenance activities. Conversely, visible maintenance needs serve as a motivator, as users are more likely to take action when problems become apparent.

Motivation for maintenance is primarily driven by short-term problem identification and immediate solutions rather than long-term planning. Participants tended to act, mostly when they noticed visible issues such as dirt, noise, or lower quality functioning of the appliances and were encouraged by quick, noticeable improvements.

While long-term benefits, such as product durability and safety, are sometimes recognized, these outcomes were often not directly linked to routine maintenance behaviors due to the inconvenience of planning and having to remember those plans.

Social interaction was also found to plays a role in enabling maintenance capabilities, as participants often rely on others for assistance and knowledge, though shared ownership can sometimes reduce personal responsibility. Furthermore, the findings suggested that upbringing can influence maintenance attitudes, particularly among older participants who were raised with values emphasizing the importance of caring for possessions.

Overall, the results of the study show that maintenance behaviors are often reactive, instead of proactive, effected by a combination of physical barriers, lack of awareness of necessity and consequences of maintenance, social influences, and visible triggers, with a clear preference for accessible, immediate solutions over long-term, proactive maintenance planning.

10.3 Design specifications and development

RQ 3. What does a tool look like that will trigger the product user to improve their EEA maintenance behaviors?

Design requirements were set up based on the insights from the performed research. These requirements explain what a tool **should** look like. These are therefore the first, but not the final step in answering RQ3. In order to sufficiently answer RQ3, design choices were made that led to various design elements.

Design requirements

The visibility (requirement 1) of the tool is the most essential requirement, not only to function as a reminder (requirement 2) of necessary maintenance activities but also to effectively trigger awareness (requirement 3). However, because of the visibility, the tool will take up space in the user's day-to-day household environment and should therefore, without being intrusive, have a timeless aesthetic (requirement 4). In doing so, it must offer user autonomy by offering stylistic choices for personal preferences, increasing intrinsic motivation through autonomy and relatedness. The communication must be neutral and unbiased information (requirement 6). However, the tool should not provide detailed instructions or act as a manual, but instead communicate persuasive, emotionally driven messaging that evokes desire and/or value for maintenance behaviors (requirement 5). It should highlight the positive outcomes of maintenance and/or the potential negative consequences of non-maintenance.

Design goal and vision

Goal:

*"People that buy a new appliance, or currently own a functioning one, will become more **aware** of what maintenance is necessary for their appliances. They will also start valuing the **positive consequences** of maintenance activities over the **negative consequences** of non-maintenance. They will be reminded of the importance of maintenance on a regular basis by visible triggers with a timeless aesthetic. The tool will therefore **motivate**, **inform** and regularly **remind** people about necessary maintenance activities for their electric and electronic household appliances.*

Vision:

*As a result of people taking better **care** of their electric and electronic household appliances, long-term durable impact will be made when products **last longer**, and E-waste will therefore be reduced."*

Design elements

The choice was made to develop magnetic flashcards, to be attached onto its corresponding appliance. Elements of this concept were prototyped and tested, in order to develop a fitting and effective tool for the objectives of this thesis. Elements of the tool that were addressed were:

- The dimensions of the cards (A7)
- The materials (laminated cards & bendable magnetic strip)
- Sketches and AI generated images
- Informational and triggering texts
- 5 separate variant types for personal preferences
- An addition of an option to plan your next maintenance task
- Built-in kitchen option, by installing a metal plate
- General magnetic card with QR code redirected to addtional online information source

10.4 Perceived effectiveness to change behaviors

RQ 4. In what ways can the tool change the target user's behaviors to maintain their EEA?

This was followed by a validation process, including stakeholder feedback, a focus group and feedback forms from a total of ten participants, aiming to answer RQ4.

From the stakeholder session, it was found that successful implementation of the tool would depend on its ease of use and minimal effort for explanation. It is concluded that if user acceptance is confirmed, the willingness of stakeholders to participate in distributing the tool is likely, especially from the producer's side.

It is important to recognize that this validation phase analyzed perceived behavior change, and not actual long-term results. The results from the focus group and the feedback forms indicated that the tool has potential to significantly improve people's maintenance behaviors. Participants mentioned that the visual appeal and physical placement of the tool are essential to continued use. The feedback suggested that the tool works not only by informing users but also by triggering maintenance awareness into their everyday environment. While the level of acceptance varied between individuals, the tool was generally perceived as a positive influence on behavior, either by making users more aware of necessary maintenance tasks or by improving how they perform it. Most participants expressed that the cards would function as an effective visual trigger and recurring reminder.

In conclusion, the validation findings indicate that the tool has the potential to bring awareness to the user about maintenance necessity and is able to function as a visible reminder for the recurrence of maintenance.

10.5 Answering the main research question

Main research question: What does an effective communication tool and strategy look like, that can lead targeted EEA users to change behaviors toward better maintenance of their EEA?

Though hypothetically, an effective communication tool and strategy, according to the objectives of this research, can take form in various ways, the main research question is addressed in this paragraph, by describing the insights from the research that were implemented into the final design, as this is the way that the conclusions were drawn for this thesis.

Research and design focus

The main focus of this research and therefore also for the final tool design was the period when the product functions as required, in which the user can take action to perform maintenance activities. The decision was made to focus on periodic maintenance, because when maintenance tasks are categorized based on amount of

effort and frequency of necessary action, these are assumed to be where motivation is tends to be lacking.

The targeted users of the tool are those who are already open to the idea of adopting maintenance behavior. The communication strategy targets motivations beyond sustainability, such as saving money or reducing effort, to encourage the desired maintenance actions. The tool targets users who are willing but not always aware or able to remember necessary maintenance, enabling them to turn their willingness into action.

Raising awareness

The user interview participants often lacked knowledge, neither did they take initiative to seek it out without awareness of their lack of knowledge. Therefore, the tool brings awareness about necessary maintenance, since this is essential for motivating behavior change. Currently, seeking out maintenance information currently requires consumers to initiative and without awareness of their knowledge gaps, they are unlikely to take action. The tool also communicates why the maintenance tasks are necessary and provides a neutral and reliable source of maintenance information, not influenced by prescriptions from one specific producer.

Visibility and short-term consequences

Physical accessibility as well as visibility are central to the tool, because these elements were found to be essential for maintenance behavior to occur. Short-term consequences (e.g., dirt, noise) are able to trigger maintenance behavior, and are therefore emphasized in the communication of the tool's design.

User Perception

The perception of necessity of maintenance was found to play a role in whether someone will look up information. The tool communicates this necessity through triggering images and text, because someone becomes aware of this, there is a lot of information accessible for someone to take the next steps in performing maintenance.

Participants often overestimated how difficult or time-consuming maintenance would be. Basic explanation of how little effort is actually needed can increase confidence and likelihood of action. The tool tries to change the user’s perception of their own ability for maintenance, and change their perception of effort of the maintenance tasks, through explaining the maintenance tasks in a simple and concise manner, in contrast to user manuals, which users avoid due to their complexity, length, and excessive information unrelated to maintenance.

Recurring motivation

The tool emphasizes motivational aspects, encouraging maintenance activities. This is currently missing in user manuals, which contain all the required and necessary information about the appliance, not mainly focused on maintenance, and also not specifically aiming to motivate maintenance behavior. As a result, it often becomes a condensed booklet that lacks elements for persuading (maintenance) behaviors.

The communication for maintenance focuses on encouraging motivation, also because rental-lease constructions are shifting the incentive for maintenance away from the product user.

The tool should support quick solutions while also nudging users toward long-term planning and recurring motivation. The tool should function as a recurring reminder, as most people are capable of performing maintenance but tend to forget over time and lose awareness of its importance. Long-term benefits like durability and safety as emotional payoffs that give satisfaction. Though not a primary motivator, participants appreciated durable products or cleaning for safety. This should be used in the tool’s messaging to support habit reinforcement.

Intervention strategy

Since new regulations have made businesses increasingly aware of the necessity for circular actions by requiring more transparency and to communicate reliable data to consumers, the long-term strategy that goes with the final tool concept encourages circular user behaviors, and in doing so enables collaboration between businesses and organizations. The final intervention and strategy also enables the upcoming mandatory Digital Product Passport (DPP) to be accessed, because businesses will require to provide this access and are therefore already incentivized for this cause.

Chapter 11
Discussion

This chapter starts with a discussion of the **methodology choices**, touching on decisions made throughout the process of researching literature, turning literature insights into interviews, and with the results, the methods that were used to develop the gathered insights into a substantiated tool design for encouraging maintenance behavior.

Then, the **problem statement** of excessive E-waste and what decisions were made in approaching this topic along with the **context** is discussed. A demand for an intervention directed specifically at maintenance behaviors was what initiated this thesis project; however, the concept of maintenance had to be defined more narrowly, because of a definitional grey area overlapping with DIY repair. Decisions that were made in order to interpret this topic and their implications are discussed and argued for.

The chapter then continues to touch on relevant findings from the research, about its significance to the literature and relevance for designing the tool to encourage better maintenance. **Motivational necessity** came up throughout the research findings and was found to be an essential subject for discussion.

The following paragraph discusses what influenced and inspired the **design choices**, although they mainly relied on the prior research done during this project, they also were influenced by other factors like intuition, personal preference, time restriction, and more. Furthermore, the chapter concludes with **recommendations** for further research, as well as for further intervention design regarding maintenance behavior, that the discussion naturally has brought about.

Overall, this chapter takes a critical perspective on decisions that were made throughout the entire process, by explaining the reasoning behind them, discussing the significance of conclusions drawn from the research, and recognizing the limitations that the methods brought about.

11.1 Methodology choices

Literature review

Beginning this thesis project, a literature study was done, initially to set up a theoretical framework for maintenance behavior. This proceeded almost the entirety of the project, ultimately resulting in a separation of the literature study into a framework for maintenance behavior and a framework for persuasive intervention design. The scientific search engines that were used were mostly Scopus, and Google Scholar. Keywords like 'behavior', 'motivation', 'product', 'maintenance', 'sustainability' and 'intervention' were most often used. In Appendix D, an extended explanation of the literature review methods can be found.

Initially, the suggestion was made by the Behavioral Insights Team (BIT) to use the COM-B model of behavior (Michie et al., 2011), because this model is commonly used within the government when analyzing behavioral patterns and creating interventions for behavior change. After more literature analysis, Fogg's model of behavior (Fogg, 2009) was also found to be a relevant model to use, as the paper by Ackermann et al. (2018) uses this model specifically to analyze design for product care, and adjusted the model specifically to the context of product care (see Figure 13). These two models were easily combined, as they both identify motivation as an essential driver for behavior, only Fogg's model identifies factors of ability as the other driving force for behavior and the COM-B model separates ability into capability and opportunity.

The combined model of behavior separates motivation and (cap)ability from each other. Motivation was found to be more relevant to research as a scientific concept than ability and opportunity. Therefore, the choice was made to do an extensive literature study into motivation in relation to maintenance behavior. The theoretical framework extended the concept of motivation with concepts like momentary wants and needs (PRIME), intrinsic and extrinsic motivation (SDT), and expectancy-value (EVT). Though other models and concepts would likely have led to different approaches and/or results, these were selected for the theoretical framework for maintenance behavior, due to their distinct yet complementary analytical values toward motivation and behavior.

From theory to interviews

Because the user interviews were part of the exploratory phase, the choice was made to follow a semi-structured approach for the protocol. This resulted in an environment where the participant could talk openly about any experience that could be relevant to the research. However, this also resulted in the conversation topics deviating to unrelated topics.

For future research, it would be more useful for such interviews, relating to maintenance experiences, to adhere to a stricter interview structure. Instead of semi-structured interviews, structured interviews could give more insights into specific maintenance activities.

The interview questions were formulated based on the theoretical framework of behavior. The intention was not to approach the interviews with the mindset that they should result in a design proposal. The notion was that this would create biased answers from the participants and influence the results of the interviews. The goal of the interviews was to get an in-depth user perspective on EEA maintenance behaviors. Although they were not discouraged to bring up solutions for maintenance problems themselves, which occasionally they did.

Conversations and interviews

The contacts for the exploratory interviews with field experts were acquired through the network of the LLE coalition and the Ministry of I&W. Attempts were made to contact field experts outside of this network through email contact, however, this approach did not manage to gain more field experts to interview. A valuable perspective would have been that of the companies that solely produce maintenance tools like HG or Eccellente. These companies have different incentives for gaining profit, especially regarding providing neutral and unbiased maintenance information. This additional perspective could have provided deeper insight into answering RQ1.

The recruitment of participants for the user interviews was limited by the connections that were available at the time. The participants for the user interviews were contacted through an open request for anyone interested to participate in the research. It was expected that most of the replies would come from people that already environmentally conscious, because the request was sent in personal circles of TU Delft students, a WhatsApp group chat of volunteers in the city of Delft and through forwarding the message to friends and family.

This approach was deemed sufficient, as it was concluded that environmentally conscious people that do not perform sustainable behavior were an appropriate target group, as concluded in Chapter 3 Field Expert Perspectives from the conversations with representatives from Milieu Centraal. Nevertheless, there were doubts whether this method would result in enough diverse perspectives on maintenance behaviors, because within similar circles and for people that already show an interest in the topic, they might be similar in their values and pursuit of sustainable behaviors. A different approach to the recruitment of participants would likely generate different results. Regardless, it turned out that several participants did not perform maintenance sufficiently, even though all of them considered themselves as environmentally conscious and were able to provide relevant insights to the research.

The process of coding the interview transcripts is inherently influenced by personal intuition, because it is based on recognizing themes and the perception of relevance of statements that are made. However, by placing the code categories within the theoretical framework, the intuitive elements were aimed to be accounted for by providing theory-based argumentations.

From theory and interview results to design methods

The challenge was to turn the results from the interviews and insights from the literature study into a basis for the creative process. The method for this was to confine the creative process within a set of design specifications. With a list of requirements, a design goal was formulated and that was then used for the next phase. This process, as mentioned, was based on research results and literature, but was also inherently influenced by intuition, like the estimation of importance of each selected requirement.

The brainstorming, ideation and concept selection was then based on design methods, like 'how-to's', Harris profiles and the weighted objectives method, taken from the Delft Design Guide (Van Boeijen et al., 2013). These methods are commonly used in design environments and rely on intuition and creativity, both highly influenced by unpredictable factors, depending on the preferences and experiences of the participants.

Some limitations that the design methods brought about are to be acknowledged. The brainstorming sessions, for example, could have been performed more extensively, particularly through a more diverse group of participants to introduce a wider range of perspectives and experiences. Additionally, although the Harris profile and Weighted Objectives Method offered structure to the selection process, they still rely on intuitive judgments, making the process of how weights are assigned or how criteria are prioritized depending on the person performing the methods.

In order to account for the unpredictable factors that are influencing the choices throughout the design methods, regular feedback (both formal and informal) from supervisors, colleagues and students was utilized throughout the entirety of the thesis project.

Validation of the design

Due to the amount of time that this thesis project could take, it was not possible to test the tool's effectiveness over a sufficient amount of time. In terms of validation, the methods primarily captured participants' perceptions of the tool's potential to influence their behavior, through a pilot focus group and through feedback forms, asking questions on whether people perceive the tool to effectively change their maintenance behaviors. The circumstances did not allow for long-term assessment of actual behavior change, which limits the ability to draw concrete conclusions about the tool's long-term impact.

The literature implies that an intervention and behavior can be cause and effect to one another, but there could be circumstances where new behaviors will occur that cause a behavioral rebound effect (Bączyk et al., 2024), which is described as the 'lower-than expected environmental benefits resulting from unintended changes in consumer behavior, triggered by the implementation of circular business models.' This suggests that, though it is possible to study whether people's perception of their maintenance behavior and also whether the periodic maintenance occurs more frequently, it cannot be assumed that improved maintenance behavior achieves lifetime extension of EEA and therefore decreases E-waste.

11.2 Problem statement and its context

Interpretation of the initial assignment

This thesis is about user behavior and specifically focuses on motivations for EEA maintenance, which is one of several product lifetime areas to focus on for establishing product lifetime extension (PLE), as portrayed in the Butterfly Diagram (Ellen McArthur Foundation, 2019). There are more ways to contribute to the shift toward a circular economy. Maintenance activity should be encouraged in order to optimize use.

The problem of E-waste excess is complex and therefore demands more than one solution, because PLE concerns a variety of different stakeholders; initiators, users, buyers, deciders, influencers and gatekeepers (Blythe & Martin, 2019). The focus for this thesis is on the EEA user and their behaviors. However, because they exist

within a complex system, involvement of all stakeholders is crucial for successful intervention.

The Ecodesign Regulation enforces the shift from production of products to maintenance, re-use, refurbishment, repair and second-hand sales (European Commission, 2022). The regulations imply that businesses will have to shift from the linear economy toward circular economy business models. It was concluded that this provides the opportunity for collaboration between businesses and organizations aiming to encourage the consumers to shift toward circular action as well. The tool does not account for businesses that have no interest in extending the use phase of their products. Convincing these businesses would require a different approach.

Definitional grey area for maintenance

The research focuses on EEA user's maintenance behaviors, because this is believed to be a neglected topic when it comes to circular behavior interventions. In the reviewed literature and related sources, maintenance activities are often grouped together with DIY repair activities or included in the general user phase (Ackermann et al., 2018; Ellen McArthur Foundation, 2019; Torca-Adell et al., 2024; Bocken et al., 2016). Regarding actions by companies, maintenance is often overshadowed by a preferred focus on professional repair (Witgoed Brigade, 2024). Therefore, the decision was made to differentiate maintenance from DIY repair, also because this the European Commission defines maintenance, which is 'an action carried out to keep a product in a condition where it is able to function as required' (European Commission, 2022), which does not concern repair activities.

A variety of studies address circular practices, such as acquisition, usage, failures, lifespan, repairs, storage, and disposal, others concentrate specifically within these areas (Torca-Adell et al., 2024). There seemed to be a gap in research addressing motivations specifically behind periodic maintenance activities, like decalcifying, thorough cleaning or filter maintenance. The hypothesis was that maintenance requires a different type of motivation, because for periodic maintenance the user is not triggered/motivated by the fact that the product has broken down, which is the case for DIY repair. The type of maintenance where this is especially prevalent is periodic maintenance.

11.3 Motivational necessity

This paragraph goes over how the research findings led to the recognition of the necessity for motivational elements for maintenance behavior, and therefore also for the final tool.

The user's perception vs. actuality

A general theme that came up for multiple different results and conclusions, was the difference between the user's perception of things and the actual situation. For example, it was stated by an expert that the consumer is capable of more than they often think themselves, indicating that capability should not be a barrier for maintenance behavior, however one's perceived competence/capability was identified as a significant barrier. The expectancy-value theory addresses this by defining the expectation for success and task value as essential components for motivation (Wigfield & Eccles, 2000).

When addressing the contradiction of perceptions and actuality regarding maintenance behavior, it is important to understand the ways that perception occurs for EEA users.

1. Perception of one's own competences
2. Perception of difficulty of the maintenance tasks
3. Perception of effort to obtain the right information
4. Perception (or awareness) of necessity of maintenance tasks
5. Perception of the (long-term) effects of maintenance

The tool ultimately aimed to change these perceptions. By keeping the maintenance information simple and concise (1, 2 and 3) and communicating both the negative consequences of non-maintenance (4) and the positive consequences of sufficient maintenance (5).

Physical factors of motivation

The combined model distinguished between (cap)ability and motivation. However, instances where the physical environment influences motivational factors were identified in the research. The COM-B model includes this relationship (Figure 13). The most significant instance for this is how participants mentioned that when issues become visible or noticeable (i.e. dirt, taste or noise), they had said they would feel motivated to perform maintenance. Similarly, when an appliance does not immediately show that maintenance is necessary, this will become a barrier for maintenance. For instance, a kettle with a see-through housing shows the accumulation of limescale inside, compared to most regular kettles.

The design of the product was mentioned more often. Instances of this were when a spot is difficult to reach for cleaning or when the minimalist design makes it difficult open the product, for instance when a filter needs to be changed or cleaned. A solution to this issue could most obviously be changing the design of the product. However, it was decided during the ideation phase for the tool that redesign would not be a sufficient option, because it would not solve maintenance issues for products currently owned or on the market. A redesign necessitates more production of EEA, and turning current inefficient EEA into waste, and this was therefore considered as not circular enough.

Short-term vs. long-term thinking

Another reason why motivational aspects were found crucial was the differing attitudes toward short-term and long-term consequences. A decrease in quality of functioning of the appliance, clothes that come out of the washing machine less clean, a vacuum cleaner that makes unusual noise, or dirt that accumulates inside of an oven, these were all found to be triggering maintenance, due to these consequences being noticed in the short-term.

However, the consequences of not performing periodic maintenance were often not noticed. Long-term consequences are not (directly) visible. Moreover, people tend not to be able to estimate the impact of external, long-term effects or predict their associated outcomes (Van der Wal et al., 2018). Long-term thinking would be considering the lifetime of the product or saving money over a long period of time, which also requires intrinsic motivation (Ackermann et al., 2018). For that reason, the developed tool was made to make these outcomes visible, encouraging the mindset of long-term thinking, not only to create awareness, but also encouraging a shift in mindset, how we care for our belongings and consider the long-term value.

Recurring motivation

Recurring maintenance necessitates recurring motivation. A one-time behavior is therefore not enough. The literature suggests two categories of interventions for influencing behavior, antecedent and consequent interventions (Abrahamse et al., 2005). Both of these were deemed relevant for effective behavior change when it comes to maintenance behaviors, because of its recurring nature, both before and after the behavior takes place. Therefore the tool aimed to provide long-term visible, recurring triggers.

Opportunity vs. initiative (learning about maintenance)

It was found that even though there are various ways for product users to acquire information about the necessary product maintenance for their appliances, they will often still lack sufficient knowledge and awareness about the necessity of maintenance. It was concluded that in these instances, the initiative will not be taken. Accessible sources of information lack the ability to trigger the user to take initiative, in the first place to acquire or retain the information.

The most significant example of this is the instruction manual. Every appliance comes with it, therefore the opportunity for learning about maintenance is present, however users are not incentivized to read this recurringly. Another example is the accessibility of tools and communication about prescribed maintenance products. The results indicated that people perceived communication about prescribed products to be biased, and desired better, more neutral alternatives. However, it was found that upbringing and neighbors helping each other influence maintenance values and behaviors positively. These factors are understood as social opportunities within the COM-B model.

This discrepancy between the availability of opportunities and the lack of user initiative should be recognized. It suggests that simple solutions, such as improving manuals or offering better tools, may not be sufficient. Instead, underlying values and social norms should be further explored, especially in relation to intervention design, in order to bring about long-term behavioral change.

11.4 Design choices

Design to nudge

An i intervention for behavior changes inherently uses persuasive communication design. Questions about the ethical consequences of such an intervention therefore needed to be taken into consideration.

Autonomy and therefore also motivation (Ryan & Deci, 2000), is in some sense 'taken away' by the current designs of the appliances concerned. Several participants mentioned how most designs do not invite them to want to understand how it works and what it needs to keep working properly. Even though the steps necessary for maintenance are not (supposed to be) complex for the average user, and the outcome of lifetime extension is desirable for any appliance owner. Persuasive design in the form of a nudge can steer us 'in the direction of what we consider to be in line with our overall preference structure' (Bovens, 2009), which is also what the tool aims to accomplish. In doing so, the design aims to uphold an ethical standard in its nudging characteristics by providing transparency of information, while enabling autonomy for the desired behavior change.

Increasing capability by bringing awareness

The choice was made to focus the development of the tool towards bringing awareness to the user. This decision was made because it was stated by multiple field experts that the consumer is capable of more than they often think themselves, indicating that capability should ideally not be a barrier, however the perception of one's own capability does seem to become a barrier for maintenance behaviors.

The participants that mentioned room for improvement of their own maintenance behavior, did not usually perform the maintenance activities with the goal of product lifetime extension, which could be a long-term goal, but they did it for short-term results. Even though all of the participants claimed that they are environmentally conscious in their day-to-day life. This indicates that the awareness of long-term effect is lacking. This lack of awareness of information could be described as a capability issue, because the environment does not sufficiently inform these people about what maintenance is necessary.

Tool development process

Insights from the research results functioned as a basis for the tool development. However, the choices that were made throughout the process of drawing, creating images and prototyping also relied on intuition and preferences, which are personal and circumstantial. Different circumstances would result in different drawings, variants

At first, drawings were inspired by Picasso's one-liners. Once it was found that AI image generators could be used for interesting other styles, the process of generating appropriate images was started. The use of AI came with its limitations, because the generators often added unwanted elements to the images. However, due to the time frame that this project was in, it was found that the AI aided in creating enough images more time-efficiently.

Variants of the cards were made to account for personal preference. The aesthetic choices and selections were made based on intuition and design experience but also using popular/successful inspirations like famous artists, games and comic books, in order to rely on the successes of those inspirations.

11.5 Recommendations

Recommendations for further research

Further research into development of interventions should aim to obtain a deeper understanding of how perception is influenced in the context of maintenance behaviors and consequently try to negate the mismatch that has been found for the various aspects of perception in relation to actuality.

This research brought qualitative results. Further research into periodic maintenance behaviors should include quantitative analysis of a larger group of people and possibly over a long period of time, to test the effectiveness of such interventions, and look into which of the different identified triggers, drivers and barriers are most influential in a practical setting, and which are less effective.

It was decided to focus on users that are already environmentally conscious, or are willing to perform maintenance for another reason (e.g. money, upbringing, values) after the conclusion was drawn that these people are best to reach for behavior change. However, this leaves out the large group of users that are likely more essential to reach in the larger context of the goal to shift toward a circular economy. Future research should focus on people that are not already environmentally conscious. Moreover, further research could expand to target the professional sector appliance users as most research on circular interventions has been neglecting the professional sector (Torca-Adell et al., 2024).

Due to the time constraint of this thesis project, the tool was only validated through a pilot focus group and through feedback forms. This means that only people's own perception of the effectiveness of the tool on maintenance behaviors was tested. For an optimal analysis into such a communication tool and its effectiveness, should aim to test the impact on behavior over a long period of time, because the long-term consequences, and the recurring characteristic of periodic maintenance is what distincts periodic maintenance from other types of maintenance, and this distinction is why issues like not remembering to plan, or not being aware of the long-term effects come up.

Recommendations for future intervention design

A recommendation for developers of similar communication tools, should consider not using AI image generators for creating the visuals. As of now, the images created by AI assumingly seem new and interesting, but it is likely that over time, these types of images will be used and seen more often in daily life and therefore also be recognizable as AI generated, and people will become exhausted. There is also more opportunity to effectively customize the visuals when a professional artist is assigned to create the images.

Further intervention developments could focus on the user's awareness of the relation between maintenance and lifetime extension. As was found in the user interview results, even though participants considered themselves environmentally conscious, they did not always relate product maintenance to lifetime extension when deciding to perform maintenance. Bringing this awareness was included into the final tool concept, by displaying a sentence to each magnetic card that mentions a fact about lifetime extension. However, this element of the design could have been emphasized more. Especially for the people that value a sustainable lifestyle, a design that emphasizes the positive sustainable impact will be expected to function as a trigger for improving behaviors.

A qualitative approach was chosen for the method of validation of the tool. Further development of such an intervention will be more effectively validated through long-term quantitative validation methods.

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Appendices

A. Maintenance categorizations Miro
B. Field expert interviews
- B.I Miro board

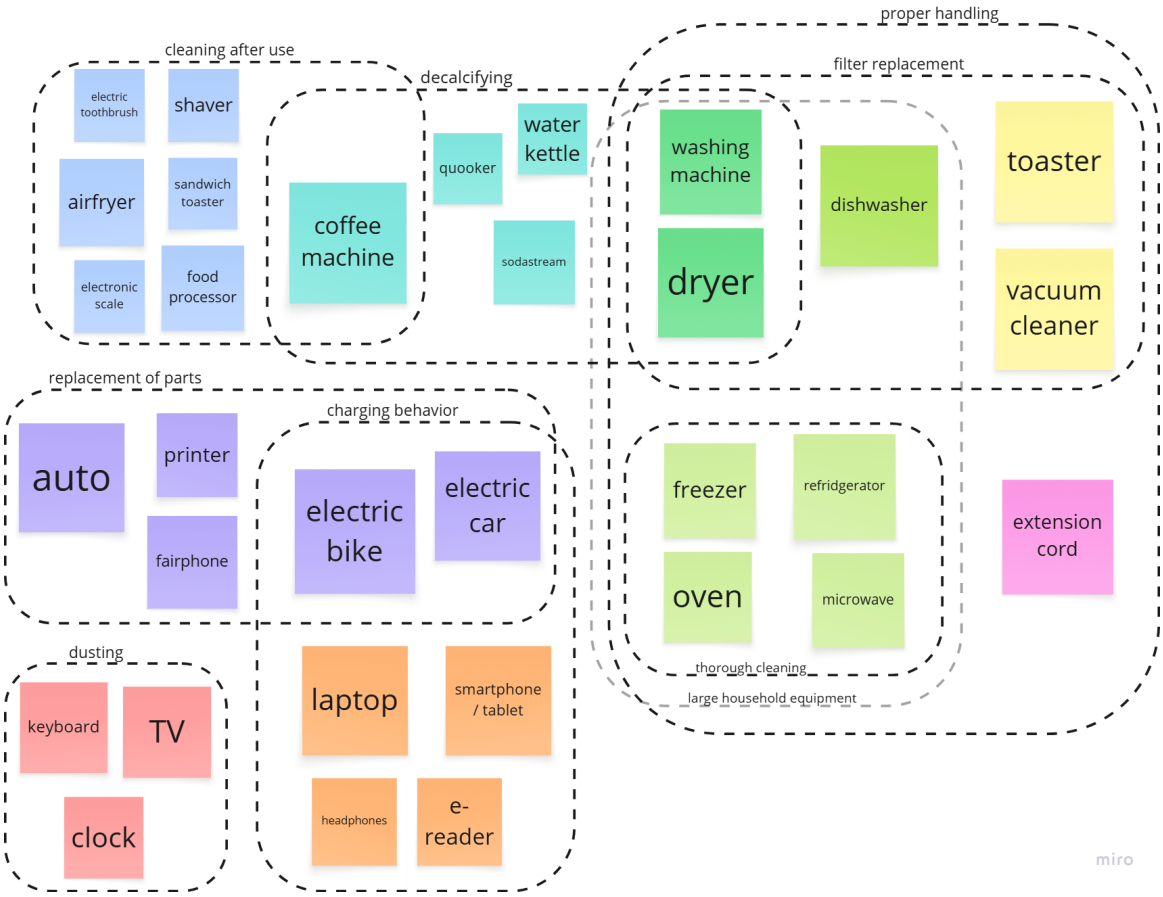
C. User interviews
- C.IV Participant request messages
- C.V Information participants
- C.VI Informed consent form template
- C.VII Personal information form template
- C.VIII Interview protocol
- C.IX Codes data

D. Literature study
E. Design specification method
- E.I Miro board

F. Brainstorm sessions
- F.I Set-up
- F.II How-to scans
- F.III Results
- F.IV Additional brainstrom Miro

G. Weighted Objectives Method
H. AI image prompts
I. Validation: Focus group & feedback forms

A. Maintenance categorizations Miro





B. Field expert interviews

B.i Themes, codes and quotations

1a. Capability

ID	Document	Quotation Content	Codes	Reference
8:4	Gesprek Repaircafe Martine Postma.docx	Mensen komen ook met een stofzuiger waar nooit de filter van vervangen is, of als er een prop in de slang zit. Dan zijn ze zo weinig onderzoekend, dat ze dan denken nou hij is stuk.Terwijl als je dan daarna gaat kijken. En je denkt oh ja de filter zit gewoon helemaal vol met ronde haar. Logisch dat die dan niet meer goed werkt. Of dat je een brommend geluid krijgt. En als je dan de filter vervangt en dan is het geluid weg. Dan doet hij het weer. En dan begin je te snappen van oh ja, ik moet ook zelf wel wat doen. Ik moet ook zelf een beetje goed voor zorgen.	Capability Functioning of the product Information	58 - 58
8:5	Gesprek Repaircafe Martine Postma.docx	veel professionele reparateurs en ook productfabrikanten die doen vaak heel krampachtig over reparatie. En zeker reparatie door een vrijwilliger. Het idee wat zij willen overbrengen is dat het heel gevaarlijk is en dat je er niet aan moet beginnen. Dat het niet voor niks is dat de apparaten zo worden dichtgesealed. En zo worden dichtgemaakt dat je niet bij de werkzame onderdelen kunt komen. Ze doen alsof dat is om de eigenaar of de consument te beschermen, maar dat is onzin. Want we zien in de Repaircafés heel veel mensen die zich echt niet laten weerhouden door de fabrikant om iets toch te proberen open te maken. Dus als het vanuit de fabrikant het idee is van, we doen dat echt voor de veiligheid van de consument, dan zou ik zeggen, geef dan juist de informatie erbij.	Barriers for maintenance Capability Information Product design Safety	101 - 101
8:6	Gesprek Repaircafe Martine Postma.docx	Je hebt bijvoorbeeld stofzuigers met schroeven die heel diep verzonken zijn. Dus dan zit er nog zo'n stuk, zit dan zo binnen in de stofzuiger. Dus heb je een hele lange schroevendraaier nodig. En die is al niet standaard.	Capability Product design	101 - 101
9:2	Gesprek ThoBo - Thomas de Boer.docx	Sommige dingen zitten gewoon, of heel erg kut in elkaar, of je denkt dat je weet hoe iets in elkaar zit, maar vervolgens weet je het niet.	Capability Product design	38 - 38
10:10	Gesprek BSH - Rob Walthaus.docx	Alles wat je kan doen zonder gereedschappen zou je aan dat klant kunnen overlaten, maar dan moet het wel op een manier die makkelijk toegankelijk is.	Capability	19 - 19
10:13	Gesprek BSH - Rob Walthaus.docx	Steeds meer apparaten gaan nu zelf ook aangeven dat er onderhoud wenselijk is. Afhankelijk van gebruiksduur. Door sensoren vastgestelde probleempjes. Bijvoorbeeld een koffieautomaat. Als je hem overkookt. Dan krijg je een verstopping. En die verstopping wordt ontdekt door de sensoren die erin zitten. En die zegt dan: Het is tijd om te ontkalken.	Capability Product design	17 - 17

1b. Reach

ID	Document	Quotation Content	Codes	Reference
6:1	Gesprek Milieu Centraal - Sophie Postma.docx	Vaak kiezen wij voor het laag hangende fruit bijvoorbeeld. Dat is dan bijvoorbeeld de doelgroep die er wel voor open staat, maar het gedrag nog niet doet en waar ook mogelijk de grootste CO2 impact bij te maken is.	Reach Wants or needs	13 - 13
7:1	Gesprek Milieu Centraal - Jelle Pothoven.docx	mensen die zeggen dat ze iets willen doen maar nog niet doen, die krijg je een stuk makkelijker mee dan mensen die bijvoorbeeld zeggen dat ze iets niet willen doen en het ook nog niet doen.	Reach Wants or needs	30 - 30
7:2	Gesprek Milieu Centraal - Jelle Pothoven.docx	wij proberen vaak die twee hand in hand te laten gaan, om wel echt gedrag te veranderen, maar tegelijkertijd ook breder zichtbaar te zijn en ervoor te zorgen dat er gesproken wordt over van alles en nog wat.	Reach	40 - 40
8:2	Gesprek Repaircafe Martine Postma.docx	De eerste mensen die ons wisten te vinden, dat was een beetje het milieu-activistische publiek. Dus mensen die echt iets voor het milieu wilden doen en tegen afval. Maar gaandeweg is het eigenlijk veel breder geworden en nu zien we eigenlijk iedereen. En er zijn ook mensen die een Repaircafé organiseren die eigenlijk niet zoveel hebben met milieu. Maar veel meer met iets doen voor de buurt. Of ze zijn betrokken bij een buurthuis wat nieuwe mensen wil binnenhalen. Of ze zoeken nog een programma voor op hun agenda om nieuwe mensen te bereiken. Of het zijn mensen die het vanuit een kerkelijke overtuiging doen.	Reach Wants or needs	36 - 36
8:3	Gesprek Repaircafe Martine Postma.docx	En je hebt ook Repaircafés die in kringloopwinkels worden gehouden. Of in bibliotheken, of in de koffieruimte van een bejaardencentrum.	Helping each other Reach	38 - 38
9:4	Gesprek ThoBo - Thomas de Boer.docx	Dat is precies waarom we die masterclass geven. Mensen een drempel overhelpen om ergens aan te beginnen. Ik denk bijna iedereen die bij ons langskomt heeft iets meegenomen wat ze al meer dan een jaar hebben liggen. Dus dat betekent dat ze het wel willen, maar dat er op de een of andere manier iets is dat ze tegenhoudt. Dus die drempel overhelpen dat is denk ik de belangrijkste voor ons.	Awareness and initiative Information Reach	68 - 68

2a. Product ownership

ID	Document	Quotation Content	Codes	Reference
10:21	Gesprek BSH - Rob Walthaus.docx	Daarnaast hebben wij natuurlijk een project, dat heet Blue Movement. Wij hebben een soort verhuur-lease-constructie, waarop producten retour komen die we dan ook weer in de markt zetten of weer aanbieden bij klanten eigenlijk. Om het te hergebruiken. Dus apparaten die nog waardevol zijn en weer gebruikt kunnen worden proberen we wel via dat kanaal er weer in te zetten.	Product ownership	40 - 40
10:22	Gesprek BSH - Rob Walthaus.docx	Je ziet wel meer dat producten delen en producten leasen of huren eigenlijk steeds meer gemeengoed gaan worden.	Product ownership	43 - 43
10:23	Gesprek BSH - Rob Walthaus.docx	Het voordeel daarvan is, dat de klant eigenlijk een oplossing koopt. Je koopt een wasmachine voor je was die opstapelt. Of je huurt hem. En op het moment dat hij het niet doet, dan stapelt het probleem zich weer op. Je was stapelt op. Met een verhuur of lease concept. Dan heb je gelijk dat ze ons bellen. En dat we gelijk adviezen kunnen geven	Product ownership	45 - 45

2b. Steps toward circularity

ID	Document	Quotation Content	Codes	Reference
8:7	Gesprek Repaircafe Martine Postma.docx	We worden de laatste tijd door heel veel bedrijven benaderd, doordat nu het recht op reparatie is vastgesteld, Europees. Zijn bedrijven wel wakker gesproken van... dit gaat dus allemaal echt gebeuren. Dus hoe gaan we dan aan onze eisen voldoen dat we reparatie gaan aanbieden aan onze klanten. En diverse van die bedrijven hebben ons dan benaderd om te vragen of we daar niet in kunnen samenwerken.	Helping each other Steps toward circularity	116 - 116
10:20	Gesprek BSH - Rob Walthaus.docx	Maar zeer zeker als je kijkt naar hergebruik, refurbished producten, recycling van bepaalde spullen die weer te gebruiken zijn, dat zijn stappen die nu gezet kunnen gaan worden.	Steps toward circularity	31 - 31
10:24	Gesprek BSH - Rob Walthaus.docx	We hebben contacten met de Kringloop. We hebben samenwerkingsovereenkomst. Die zitten in Roosendaal. Die hebben diverse filialen. Daar gaan apparaten die wij retour hebben gekregen uit de markt, maar nog goed bruikbaar zijn, die gaan daar naartoe. Die worden daar opgewerkt, opgeknapt. Met ook de certificering die ze hebben op dat gebied. Om apparaten weer in de markt te zetten. Dus de apparaten krijgen zo weer een tweede kans.	Helping each other Second-hand quality Steps toward circularity	39 - 39

3b. Awareness and initiative

ID	Document	Quotation Content	Codes	Reference
9:1	Gesprek ThoBo - Thomas de Boer.docx	En het leuke was ook dat ik daarbij heel snel zag dat die vrienden elkaar gingen helpen. Dus als ik dan eenmaal iemand had geholpen met hun tosti ijzer, en ze waren er klaar mee. Dan gingen ze niet naar huis met hun tosti ijzer. Dan gingen ze naar iemand anders met z'n fiets meekijken.	Awareness and initiative Helping each other	25 - 25
9:3	Gesprek ThoBo - Thomas de Boer.docx	Dus ik denk zeker dat je mensen kan helpen door ze beter informatie te geven, maar uiteindelijk moet het ook een soort van routine worden en ik denk dat dat voor veel mensen gewoon echt niet zo is.	Awareness and initiative Information Time	64 - 64
9:4	Gesprek ThoBo - Thomas de Boer.docx	Dat is precies waarom we die masterclass geven. Mensen een drempel overhelpen om ergens aan te beginnen. Ik denk bijna iedereen die bij ons langskomt heeft iets meegenomen wat ze al meer dan een jaar hebben liggen. Dus dat betekent dat ze het wel willen, maar dat er op de een of andere manier iets is dat ze tegenhoudt. Dus die drempel overhelpen dat is denk ik de belangrijkste voor ons.	Awareness and initiative Information Reach	68 - 68
10:4	Gesprek BSH - Rob Walthaus.docx	Als je gaat kijken naar pomp-verstopplekjes die plaatsvinden bij een apparaat, heeft dat vaak te maken met spullen die nog in de kleding achterwege zijn gebleven, dan wel een muntstuk, of iets anders waardoor een pompverstopping optreedt. Dat is gewoon een kwestie van zelf oplossen, als je handig genoeg bent.	Awareness and initiative Maintenance activities	15 - 15
10:14	Gesprek BSH - Rob Walthaus.docx	We hebben daar natuurlijk in onze gebruiksaanwijzing veel van staan. We hebben ook gezien dat dat soms weleens tot wat vragen leidt.	Awareness and initiative Instruction Manual	20 - 20
10:16	Gesprek BSH - Rob Walthaus.docx	We willen zoveel mogelijk te faciliteren wat ze zelf kunnen doen. Waardoor we minder belasting aan de telefoon krijgen. Of andere vragen krijgen. En dat is voor ons heel goed. Aan de ene kant de capaciteit met menskracht. Maar aan de andere kant weten dat de klant zelf veel meer kan. En juist dat meer doen. Als we zelf de weg vinden eigenlijk, dat vraagt nog wat motivatie en gedragssturing.	Awareness and initiative	25 - 25
10:25	Gesprek BSH - Rob Walthaus.docx	We zijn wel degelijk bezig om te zeggen welke middelen er zijn en waarvoor ze er zijn. Dus het ene middel is misschien om schoon te maken. Het andere ontkalken. En weer andere dingen waar mogelijkheden of hygiëne wordt bereikt. En dat doen we dan via alle contactmogelijkheden die er zijn.	Awareness and initiative Maintenance Tools	49 - 49
10:27	Gesprek BSH - Rob Walthaus.docx	Ook het zelf verzinnen van ontkalkingsmiddelen, wat je noemt net, azijn is soms ook geen goede oplossing. Maar dan moeten we wel dat ook mededelen, want in azijn zitten bepaalde zuren, die kunnen weer de afdichtingen aantasten. En die zuren bijvoorbeeld, die zitten niet in die concentratie in ontkalkingsmiddelen.	Awareness and initiative Information	53 - 53
10:30	Gesprek BSH - Rob Walthaus.docx	Gebruiksaanwijzing wordt vaak niet gelezen. Jammer genoeg.	Awareness and initiative Instruction Manual	66 - 66

3b. Neutrality

ID	Document	Quotation Content	Codes	Reference
8:1	Gesprek Repaircafe Martine Postma.docx	En er zijn nu meer dan 3000 Repaircafés in ongeveer 50 landen. Dus het geeft ook wel aan dat steeds meer mensen daar het nut en de noodzaak van inzien. En dat er dus meer repareerbare producten moeten komen. En dat we zorgvuldiger met spullen moeten omgaan	Neutrality	23 - 23
10:18	Gesprek BSH - Rob Walthaus.docx	Vanuit Applia kijken we daar bijvoorbeeld ook naar. Kunnen wij wat meer vanuit de branche, algemeen namens alle merken publiceren. Als je gaat kijken naar het opstellen van het apparaat, het gebruik van het apparaat, het onderhoud van het apparaat, dat zijn allemaal gelijk te trekken. Ongeacht het merk.	Neutrality	27 - 27
10:19	Gesprek BSH - Rob Walthaus.docx	Tegenwoordig staat bijna iedereen open voor duurzaamheid en circulariteit. En sowieso als je gaat kijken naar de grondstoffen terugwinning. Daar kan je niet meer van voorbij gaan eigenlijk. Dus zeker als je de circulaire neutraal economie in 2050 wil bereiken dan moet je het met z'n allen wel volgen eigenlijk. Er zijn een paar partijen die hobbelen een beetje erachteraan. En er zijn partijen die staan vooraanstaand daarbij eigenlijk. Omdat ze zien dat het gewoon de nieuwe economie is. Maar ook de nieuwe wereld die de consument eigenlijk verlangt eigenlijk.	Neutrality	29 - 29
10:28	Gesprek BSH - Rob Walthaus.docx	Een ontkalkingsmiddel van merk X is net zo goed als merk Y. En het zelf labelen geeft alleen maar meer vertrouwen vanuit de consument. Bijvoorbeeld dat merk wasmachine heb ik. Of dat merk koffieautomaat heb ik. Dus als dat ook nog eens op die verpakking staat, dan ben ik er helemaal vertrouwd ermee.	Information Neutrality	56 - 56
10:29	Gesprek BSH - Rob Walthaus.docx	Qua werking is het ongeacht wat erop staat praktisch allemaal hetzelfde. Zolang er maar niet een andere geen soda uit de keukenkastje pakt. Om te denken, daar kan ik de wasmachine mee ontkalken. Dan heb ik liever dat je een ander merk ontkalker van de fabrikant neemt. Die er wel voor geschikt is.	Neutrality	57 - 57

C. User interviews

C.i Participant request messages









C.ii Information participants

Ptc. No.	Gender	Age	Education	Household situation	Income status (p/month/household)	Interview location
1	M	26	WO bachelor	2 persons	€0 - €3.000 / student	IDE building
2	M	56-65	HBO	2 persons	Not disclosed	Home of the participant
3	F	66+	HBO	1 person	Not disclosed	Home of the participant
4	M	26-35	VWO & WO master	2 persons	€0 - €3.000 / student	TNW building
5	M	26-35	VWO & WO bachelor	1 person	€0 - €3.000 / student	IDE building
6	M	66+		1 person	€3.000 to €7.000	Home of the participant
7	M	26-35	WO master	2 persons	€3.000 to €7.000	Interviewer's home
8	F	56-65		1 person	Not disclosed	Video call
9	M & F	66+	WO diploma	2 persons	Not disclosed	Home of the participant
10	F	66+		1 person	Not disclosed	Home of the participant

C.iii Informed consent form template

Toestemmingsformulier voor deelname: EEA Maintenance Research

Interviews over gedragsfactoren betreffende periodiek onderhoud van elektrische en elektronische apparaten

Dit onderzoek wordt gedaan door Esther Meershoek van de TU Delft, in samenwerking met het Gedragsteam van de afdeling Algemeen Strategisch Advies (ASA) van het Ministerie van Infrastructuur en Waterstaat.

Het doel van dit onderzoek is om inzicht te krijgen in factoren die een rol spelen bij het gedrag van gebruikers van elektrische en elektronische apparaten (EEA) en het onderhoud van deze apparaten. Het gesprek zal ongeveer 30 tot 45 minuten in beslag nemen. Van het gesprek zal een geluidsopname gemaakt worden. Deze audio zal getranscribeerd worden naar tekstbestand waar de naam van de geïnterviewde niet vastgelegd zal worden. De data zullen gebruikt worden voor kwalitatieve analyse en voor het (anoniem) citeren bij de verslaglegging van het onderzoek.

Wij doen ons best om uw antwoorden vertrouwelijk te houden. We minimaliseren de risico's door de digitale data zonder naam op te slaan. De ondertekende formulieren worden los van de audio en transcriptie bestanden opgeslagen.

Uw deelname aan dit onderzoek is volledig vrijwillig, en u kunt zich elk moment terugtrekken zonder reden op te geven. U bent vrij om vragen niet te beantwoorden. De geanonimiseerde data worden mogelijk aan het eind van het project geplaatst op de TU Delft repository, deze dient als platform voor de wetenschappelijke output van de TU Delft, waarbij wordt voldaan aan de Open Access principes.

Voor vragen of opmerkingen kunt u contact opnemen met Esther Meershoek

1. Ik heb de informatie over het onderzoek gelezen en begrepen. Ik heb de mogelijkheid gehad om vragen te stellen over het onderzoek en mijn vragen zijn naar tevredenheid beantwoord.

2. Ik doe vrijwillig mee aan dit onderzoek, en ik begrijp dat ik kan weigeren vragen te beantwoorden en mij op elk moment kan terugtrekken uit de studie, zonder een reden op te hoeven geven.

3. Ik begrijp dat mijn deelname aan het onderzoek betekent dat de audio van het interview wordt opgenomen en dat deze getranscribeerd zal worden.

4. Ik begrijp dat mijn deelname betekent dat er persoonlijke identificeerbare informatie en onderzoeksdata worden verzameld, met het risico dat ik hieruit geïdentificeerd kan worden.

5. Ik begrijp dat binnen de Algemene verordering gegevensbescherming (AVG) een deel van deze persoonlijk identificeerbare onderzoeksdata als gevoelig wordt beschouwd, namelijk naam, leeftijd, gender, inkomen en emailadres.

6. Ik begrijp dat persoonlijke informatie en dit formulier zo veilig mogelijk, en los van elkaar, worden bewaard. Dit alles om de kans op een gegevenslek zo klein mogelijk te houden en ik begrijp dat de persoonlijke informatie die over mij verzameld wordt die mij kan identificeren niet gedeeld wordt buiten het studieteam.

7. Ik begrijp dat na het onderzoek de geanonimiseerde informatie gebruikt zal worden voor het eindverslag en de eindpresentatie

8. Ik geef toestemming om mijn antwoorden, ideeën of andere bijdrages anoniem te quoten in resulterende producten.

9. Ik geef toestemming om de data (zonder vermelding van naam) die over mij verzameld worden gearchiveerd worden in de TU Delft Repository opdat deze gebruikt kunnen worden voor toekomstig onderzoek en onderwijs en ik begrijp dat de toegang tot deze repository open is.

Naam deelnemer: Handtekening:

_____ _____

Persoonlijke informatie formulier

Gender:

❑ Man ❑ Vrouw ❑ Anders

Leeftijd:

❑ 18 – 25
❑ 26 – 35
❑ 36 – 45
❑ 46 – 55
❑ 56 – 65
❑ 66+

Diploma:

- Middelbare school diploma: _____
- MBO / HBO / WO bachelor / WO master
- Overig: _____

Woonstatus:

❑ Alleenwonend
❑ Samenwonend met partner
❑ Gezin met kinderen, aantal: _____
❑ Huisgenoten, aantal: _____
❑ Anders, namelijk: _____

Bruto-inkomen p/m voor het hele huishouden:

❑ €0 - €3.000 / Student
❑ €3.000 - €7.000
❑ €7.000 - €10.000
❑ €10.000 +

C.v Interview protocol

INTRODUCTIE

- Vermelden dat het gesprek ongeveer half uur/drie kwartier zal duren.
- Benoemen dat deelname volledig vrijwillig is en dat er geen goede of foute antwoorden zijn
- Informed consent laten invullen
- Toestemming vragen voor het maken van een geluidsopname.
- Opname starten
- Nodig de geïnterviewde uit om vrijuit te spreken, met focus op zowel positieve als negatieve ervaringen
- Bespreken van anonimiteit en afspraken rondom de verwerking van de gegevens.

ALGEMEEN (huidige situatie)

1. Kun je jezelf kort voorstellen?
2. Ben jij alleen, of samen met een partner/huisgenoot verantwoordelijk voor het huishouden?
    a. Hebben jullie afspraken over het onderhouden van jullie apparaten?
3. Wat voor apparaten heb je thuis in bezit (gehad)?
4. Waar denk je aan bij het begrip onderhoud van je apparaten?
5. Welk onderhoud voer je wel eens uit?
    a. Hoe vaak?
6. Spreek je wel eens met anderen over je apparaten en het onderhoud ervan?
    a. Ervaar je sociale druk/stimulans om je apparaten te onderhouden?
    b. Valt het wel/niet binnen je identiteit om het hierover te hebben?
7. Heb je wel eens meegemaakt dat een van je apparaten niet meer werkte?
    a. Heb je dat ooit gerelateerd aan onderhoud dat je al dan niet had uitgevoerd?

(5)

ERVARINGEN & TRIGGERS

Wanneer is de laatste keer dat je uit jezelf [apparaat] hebt ontkalkt of verontreinigd? (of een soortgelijke handeling)

    a. Wat was de situatie waardoor je dat ging doen? Waarom was dat het moment dat je dat ging doen?
    b. Wat heeft je destijds weerhouden om het eerder te doen?
    c. Wat heeft je sindsdien weerhouden om het nog een keer te doen?

8. Wat heeft je wel eens getriggered om onderhoud uit te voeren?
    a. Wat stimuleert jou om onderhoudshandelingen uit te voeren? (bv tijd, uiterlijk, huisgenoten)

[als er onduidelijkheid is over de vraag/het antwoord, toelichting over triggers. Voorbeelden van Ackermann, als bijlage]

    b. Herken je de genoemde triggers?

(10)

ABILITY BELIEFS & MOTIVATIE

9. Heb je het gevoel dat je zelf in staat bent om je apparaten te onderhouden? (ability beliefs)
    a. Waarom (niet)?
    b. Hoe goed vind je je vermogen om je apparaten te onderhouden in vergelijking toch de mensen om je heen? (schaal van 1 tot 10)
10. Wat verwacht je als resultaat/gevolg wanneer je onderhoud uitvoert? (expectation for success)
11. Heb je bepaalde gewoontes/gebruiken mbt onderhoud van [apparaat]? (automatic motivation)
12. Voel je wel eens de behoefte/noodzaak om [apparaat] te onderhouden? (wants/needs)
    a. Doe je daar dan iets mee? Waarom wel/niet?
13. Maak je wel eens plannen voor onderhoud, ruim voordat je het wil uitvoeren? (reflective motivation)
    a. Waarom?
    b. Onthoud je die plannen altijd?
    c. Heb je wel eens andere gedachten over je eigen onderhoudsgedrag?

(15)

INFORMATIE & TOOLS

14. Als je niet weet hoe je je apparaat moet onderhouden, wat doe je dan/zou je dan doen? (voorbeeld: google, handleiding, rondvragen)
    a. Hoe ervaar je dit proces?
15. Wat weet je over wat voor onderhoud nodig is voor [apparaten]?
    a. Weet je hoe?
    b. Weet je hoe vaak?
    c. Als je meer zou weten over hoe je je apparaten moet onderhouden, zou dat iets veranderen in hoe je daartoe handelt?
16. Weet je wat voor middelen/spullen je nodig hebt voor het onderhoud?
    a. Houdt het je te tegen als je naar de winkel moet voor het onderhoud?
    b. Houdt het je tegen als je informatie moet opzoeken?

[toelichting over soorten onderhoud, noemen dat het niet over reparatie gaat, regelmaat, relatie met levensduur vh product, waarom is onderhoud belangrijk? repaircafe]

17. Had je hier al wel eens zo over nagedacht?
    a. Verandert dit iets voor je intenties? Waarom?

(20)

USEFULNESS, IMPORTANCE & INTEREST ITEMS

18. Hoe belangrijk is het onderhouden van [apparaat] voor je?
    a. Waarom zou je het doen?
    b. Hoe vind jij zelf dat je dat in werkelijkheid uitvoert?
19. Ervaar je plezier, of juist niet, bij het onderhouden van [apparaat]?
20. Heb je het gevoel dat het nut heeft om [apparaat] te onderhouden?

(25)

OPDRACHT (optioneel)

21. Wat heb je [afgelopen week] gedaan? Hoe was dat?
22. Wanneer heb je het gedaan?
    a. Heb je het uitgesteld? Waarom wel/niet?
23. Hoe heb je het proces ervaren?
    a. Hoe was de aanloop er naartoe?
    b. Hoe was het onderhouden zelf?
    c. Hoe voelde je je na afloop?
    d. Hoe kijk je erop terug?

(30)

AFSLUITING

24. Ben je in je dagelijks leven bezig met duurzaamheid? (afval scheiden, groene energie, vegetarisch eten, tweedehands spullen etc.)

[Toelichting geven op het doel van het gesprek (onderzoek naar onderhoud EEA, levensduur verlengen EEA, circulariteit, minder consumeren). Gesprek is bedoeld om beter te snappen wat allemaal in de weg kan zitten en wat juist kan helpen bij onderhoud van EEA. Uitleggen hoe de informatie zal worden gebruikt en hoe de resultaten van de interviews verder verwerkt worden.]

25. Heb je nog vragen of opmerkingen?

Bedankt!

C.vi Codes data

	Interview 1 transcript.docx Gr=42	Interview 2 transcript.docx Gr=41	Interview 3 transcript.docx Gr=24	Interview 4 transcript.docx Gr=12	Interview 5 transcript.docx Gr=14
● **Bad habits** Gr=3	0	1	0	0	0
● **Barriers for maintenance** Gr=35	8	9	4	3	2
● **Clean or Dirty** Gr=31	7	8	3	2	1
● **Drivers for maintenance** Gr=69	15	14	5	5	3
● **Effort** Gr=11	1	1	2	3	0
● **Functioning of the product** Gr=28	10	5	1	2	2
● **Helping each other** Gr=13	1	0	4	0	0
● **Information** Gr=42	4	6	4	3	6
● **Instruction Manual** Gr=17	2	1	3	1	3
○ **Knowledge** Gr=11	4	3	0	1	1
● **Maintenance activities** Gr=24	3	12	0	1	1
● **Maintenance Tools** Gr=10	4	0	3	0	0
● **Neutrality** Gr=6	1	0	0	0	0
○ **Other Physical Properties** Gr=2	0	1	1	0	0
● **Planning** Gr=17	1	2	1	1	2
● **Positive experiences** Gr=14	3	3	0	2	0
● **Price** Gr=6	1	2	1	0	0
● **Product design** Gr=12	0	1	1	3	0
● **Product ownership** Gr=9	3	0	1	0	0
● **Relating to lifetime of the product** Gr=11	2	0	0	0	1
● **Safety** Gr=8	0	2	0	1	2
● **Second-hand quality** Gr=3	0	0	0	0	0
● **Smell** Gr=2	0	1	0	1	0
● **Time** Gr=20	5	4	2	0	1
● **Upbringing** Gr=7	0	3	1	1	0
○ **Use frequency** Gr=3	0	3	0	0	0
● **Visibility** Gr=12	2	3	4	0	0
● **Wants or needs** Gr=10	2	0	0	0	0
1a. Instructions Gr=56; GS=3	8	6	7	4	6
1b. Types of maintenance products Gr=26; GS=3	8	3	3	1	1
1c. Knowledge and awareness Gr=63; GS=4	9	9	5	5	7
1d. Physical barriers Gr=37; GS=5	3	6	6	5	2
1e. Interaction Gr=25; GS=3	4	3	5	0	0
2a. Long-term ideas and experiences Gr=49; GS=4	7	8	3	2	4
2b. Short-term experiences Gr=98; GS=9	23	18	9	6	4
2c. Upbringing Gr=7; GS=1	0	3	1	1	0
Context Gr=24; GS=1	3	12	0	1	1
Other triggers, barriers or motivational factors Gr=12; GS=3	1	5	1	0	0
Totals	145	158	81	55	50

	Interview 6 transcript.docx Gr=12	Interview 7 transcript.docx Gr=20	Interview 8 transcript.docx Gr=9	Interview 9 transcript.docx Gr=16	Interview 10 transcript Gr=3	Totals
● Bad habits Gr=3	0	2	0	0	0	3
● Barriers for maintenance Gr=35	1	4	2	1	0	34
● Clean or Dirty Gr=31	2	2	2	3	1	31
● Drivers for maintenance Gr=69	5	3	3	13	1	67
● Effort Gr=11	0	2	2	0	0	11
● Functioning of the product Gr=28	3	2	1	1	0	27
● Helping each other Gr=13	0	2	0	2	0	9
● Information Gr=42	2	3	0	4	0	32
● Instruction Manual Gr=17	2	2	1	0	0	15
○ Knowledge Gr=11	0	0	0	2	0	11
● Maintenance activities Gr=24	1	1	0	1	1	21
● Maintenance Tools Gr=10	0	0	1	1	0	9
● Neutrality Gr=6	0	0	0	0	0	1
○ Other Physical Properties Gr=2	0	0	0	0	0	2
● Planning Gr=17	3	3	1	2	0	16
● Positive experiences Gr=14	1	1	2	1	0	13
● Price Gr=6	0	0	0	1	0	5
● Product design Gr=12	1	1	1	0	0	8
● Product ownership Gr=9	1	1	0	0	0	6
● Relating to lifetime of the product Gr=11	0	4	0	3	0	10
● Safety Gr=8	0	0	0	0	1	6
● Second-hand quality Gr=3	0	2	0	0	0	2
● Smell Gr=2	0	0	0	0	0	2
● Time Gr=20	2	4	0	0	0	18
● Upbringing Gr=7	0	0	2	0	0	7
○ Use frequency Gr=3	0	0	0	0	0	3
● Visibility Gr=12	1	2	0	0	0	12
● Wants or needs Gr=10	0	1	0	2	1	6
1a. Instructions Gr=56; GS=3	3	4	1	5	0	44
1b. Types of maintenance products Gr=26; GS=3	0	0	1	3	0	20
1c. Knowledge and awareness Gr=63; GS=4	2	7	2	6	0	52
1d. Physical barriers Gr=37; GS=5	2	5	2	0	1	32
1e. Interaction Gr=25; GS=3	1	3	0	2	0	18
2a. Long-term ideas and experiences Gr=49; GS=4	5	8	1	4	1	43
2b. Short-term experiences Gr=98; GS=9	7	12	5	5	2	91
2c. Upbringing Gr=7; GS=1	0	0	2	0	0	7
Context Gr=24; GS=1	1	1	0	1	1	21
Other triggers, barriers or motivational factors Gr=12; GS=3	0	2	0	1	0	10
Totals	46	84	32	64	10	725

D. Literature review

For the literature research, the scientific databases Scopus, Google Scholar, and the TU Delft repository were used. In order to explore the topic of behavioral science and product maintenance, a list of keywords was compiles, consisting of words like products/appliances/devices, sustainable/mitigation, 'product lifetime' and 'behavior change'/intervention. Through snowballing method, papers were selected and abstracts were read in order to determine their relevance.

During the internship at the Ministry of Infrastructure, the COM-B model of behavior (Michie & West, 2011; West & Michie, 2020) was recommended, because this model is regularly used within governmental projects for interventions targeting behavior change.

The paper by Ackermann et al. (2018) and the Product Care Kit (Ackermann & Tuimaka, 2021) were recommended by a supervisor. Within this paper Fogg's model of behavior (Fogg, 2009) used as the theoretical model to base its studies on.

Through regular google searches, directives and relevant sources relating to the EGD (Data.Europe.EU, 2024; European Commission, 2022; European Commission, 2023; European Commission, 2024; European Commission, 2024a; European Parliament, 2024; Europees Parlement, 2020) were used to shed light on the regulatory impact the EGD has had, since its initiation.

Introduction – literature into circular economy

Further on, the snowball method was used using keywords like 'product design', 'business model', 'circular economy', 'lifetime extension' and 'maintenance', in order to obtain information about the general topic of product maintenance, as part of the circular economy, aiming for PLE.

Subject	Search terms	Repository	Hits	Source
Circular economy	circular AND economy AND business AND model AND maintenance AND product AND lifetime	Google Scholar	86,300	(Bocken et al., 2016; Tunn & Ackermann, 2020)
Product lifetime extension	Behavior AND circular AND economy AND electrical AND appliances	Scopus	7	(Reynolds et al., 2024)

Recommended within university courses:

Recommendation	Source	Objective
Course: Wicked Innovation	(Blythe & Martin, 2019)	Distinguishing stakeholders as decision-making units (DMU's)
Course: Ethics of technology	(Bovens, 2009)	Defining 'nudging'
Throughout the CDI master track	(Ryan & Deci, 2000; Ryan & Deci, 2020)	Self-determination theory, concepts of *autonomy*, *relatedness* and *competence*

The pay-per-use business model (Bocken et al., 2018) came up in one of the meetings of the EEA coalition.

COM-B model of behavior

Goal	Search terms	Repository	Hits	Source
Researching Fogg's behavior model	COM-B AND Fogg	Google scholar	606	(Gangrade & Khadilkar, 2023)
	(behavior AND change) AND com-b	Google scholar	42,200	(Willmott et al., 2021)

Other literature was either recommended through in-person discussion with supervisors (Barron & Hulleman, 2015; Wigfield & Eccles, 2000; Ackermann et al., 2018) or other experts who mentioned concept of 'temporal myopia' (Van Der Wal, 2018) and the 'rebound effect' (Bączyk et al., 2024)

Objective	Search terms	Repository	Hits	Source
Temporal myopia: behavioral concept	myopia AND sustainable AND behavior	Scopus	16	(Van Der Wal et al., 2018)
Rebound effect: negative consequence of behavior change	rebound AND effect AND behavior AND sustainable	Scopus	145	(Bączyk et al., 2024)

Persuasive intervention design

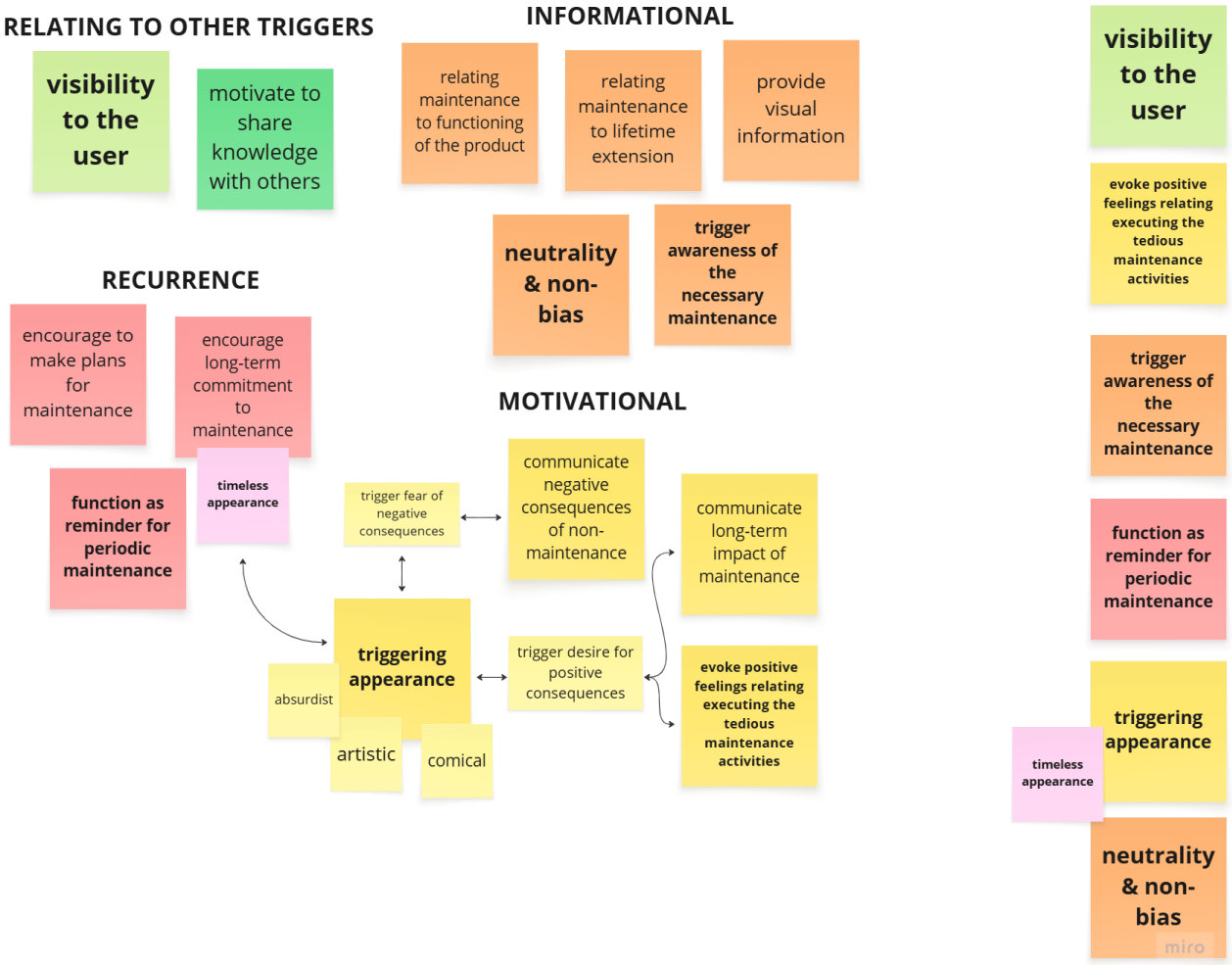
For the second half of the thesis project, the theoretical framework was extended toward persuasive communication and intervention design.

Moreover, the example of how cigarette packagings utilize *fear appeal* was researched, and through a literature search, sources were found to argue this form of persuasive communication.

Goal	Search terms	Repository	Hits	Use
Expanding theoretical framework towards intervention design	sustainable AND household AND products AND motivation AND (behavior AND change) AND (intervention OR mitigation) *snowball method*	Scopus	14,409	(Abrahamse et al., 2005; Herrmann et al., 2020)
Comparison to cigarette packaging marketing	smoking AND packaging AND Netherlands	Scopus	10	(Nagelhout et al., 2015)
Comparison to cigarette packaging marketing	Cited by Nagelhout et al. (2015)	Scopus		(Ruiter et al., 2001)

E. Design specification method

E.i Miro board



F. Brainstorm sessions

F.i Set-up

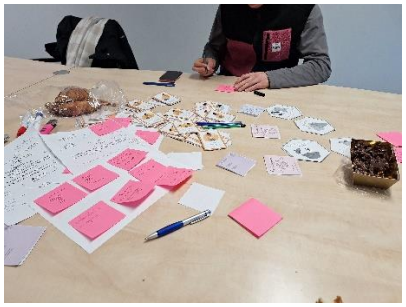
ROUND 1 – Open brainstorm	30
View Product Care Kit for inspiration	10
How To's • How can you motivate a product user to carry out a maintenance action now? • How can you make a product user remember information at the right time? • How can you create awareness amongst product users? • During sale of the product • After the installation of the product • How can you bring a tedious maintenance task to the product user in a positive way? • How can you make a product part (which needs maintenance) that is not visible, visible?	10
Clustering incl discussion	10

ROUND 2 – Elaboration on own idea	17
Direction for design concepts - **Explanation (magnet, per action, motivators)** - **Canva examples** ○ **Visual of the appliance/washing machine** ○ **Instructions (types of maintenance)** ○ **Triggers (negative/positive consequences of (non-)maintenance)** ○ **Reminder for recurring maintenance**	5
1. **Points for improvement (3 min)** 2. **Positive feedback (3 min)** 3. **Additions, additions (3 min)** 4. **Fill in a blank template (3 min)**	12

CLOSING (approx. 5 min)

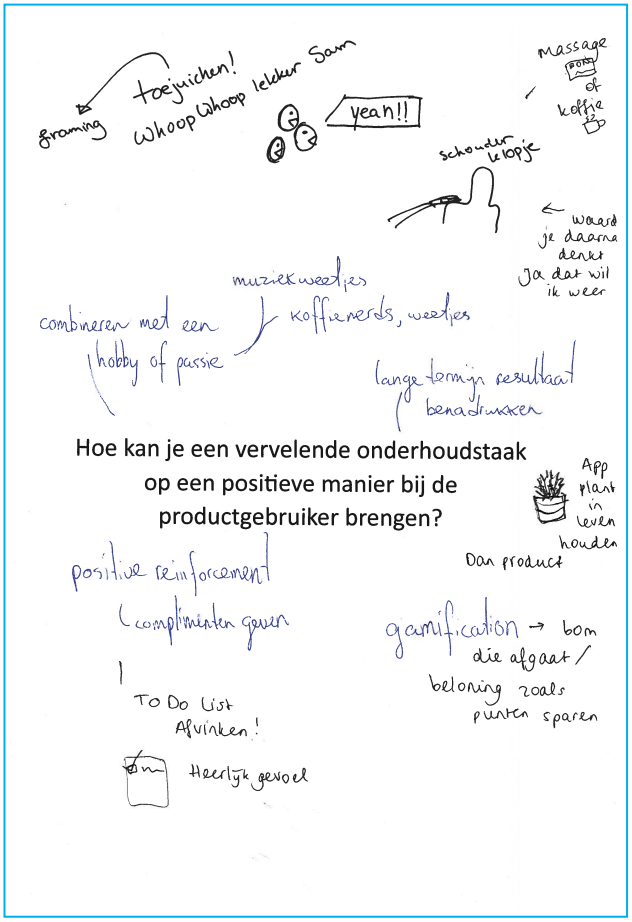
- General feedback

Photos:

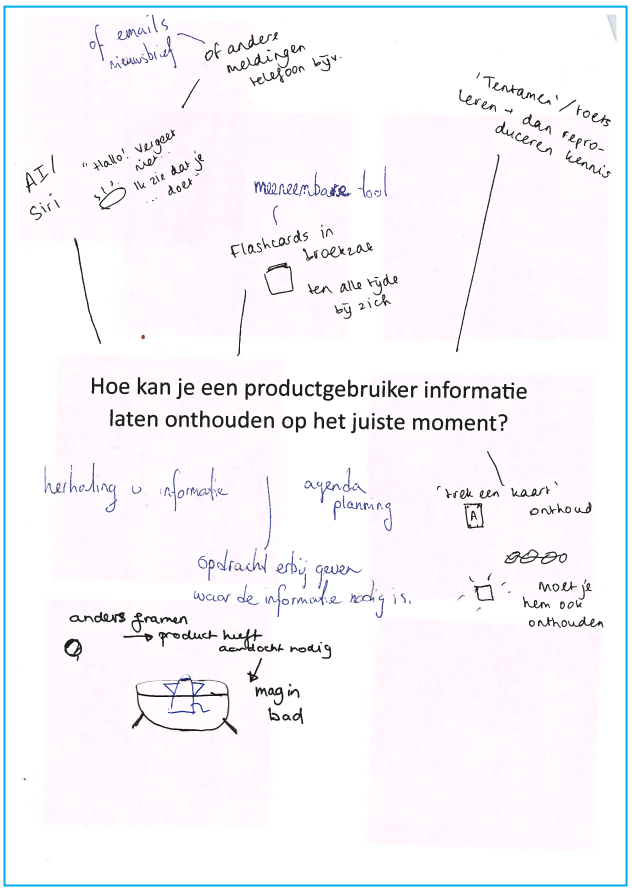


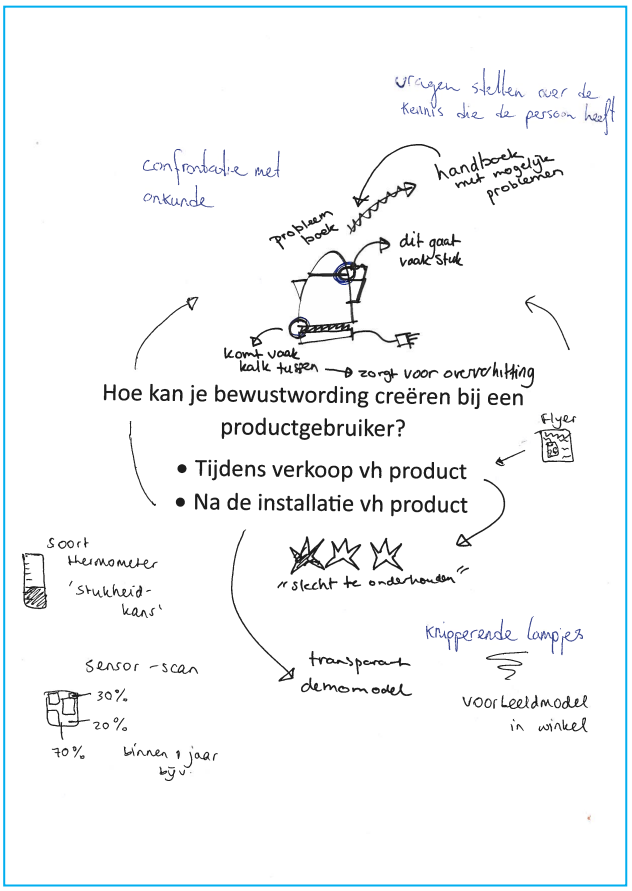


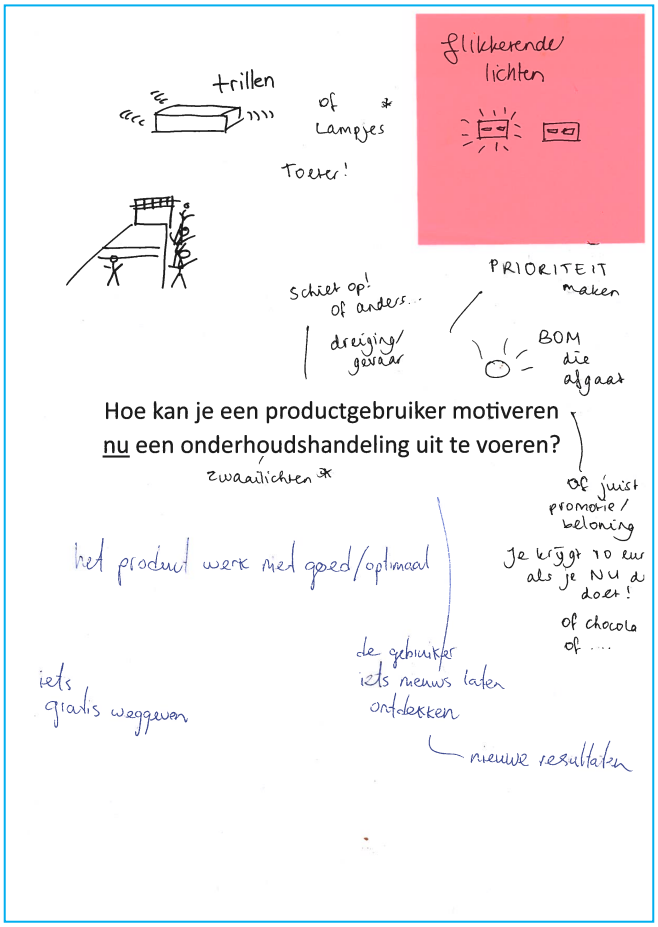
F.ii How-to scans

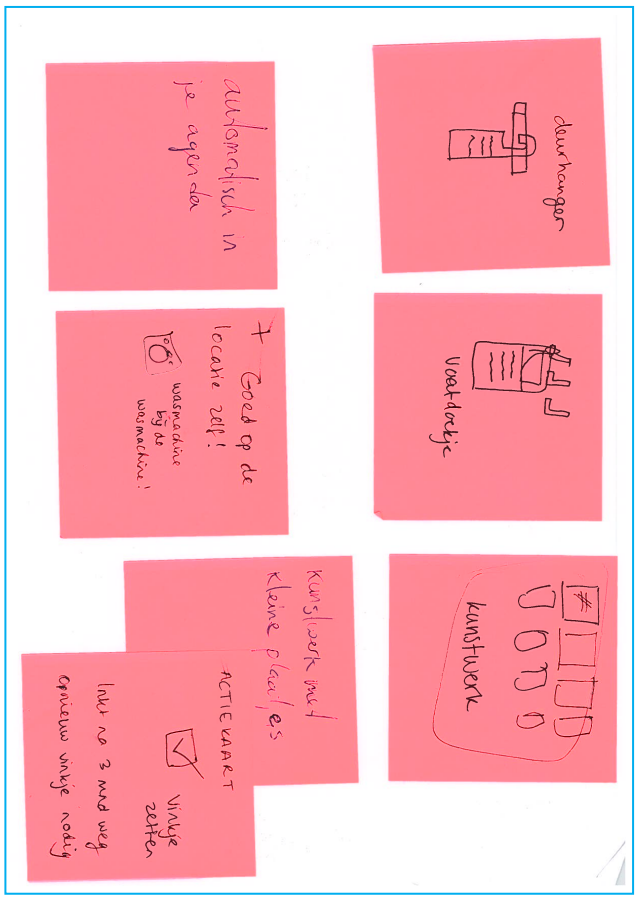


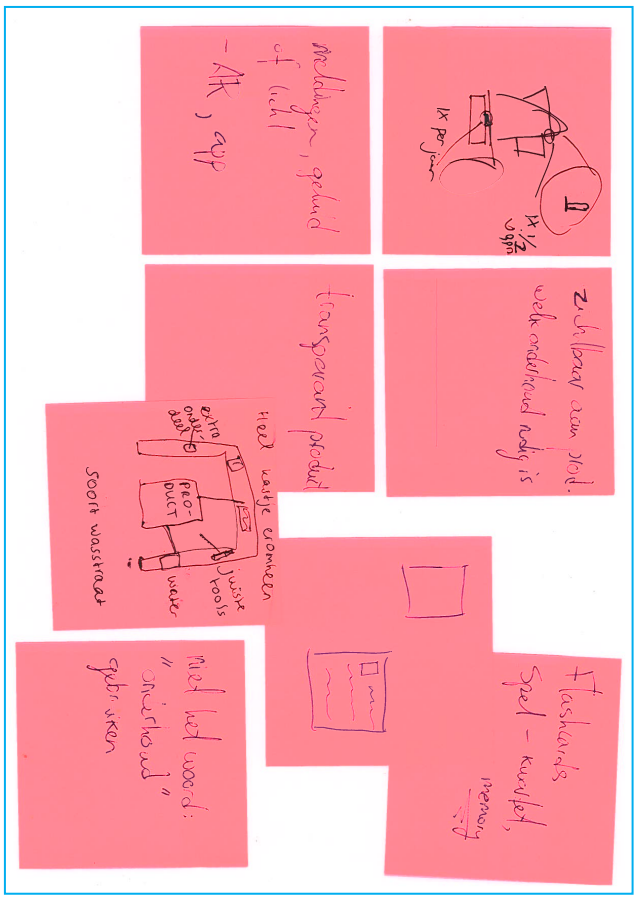




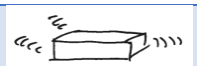



flikkerende lichten
trillen
of
lampjes
Toeter!
schiet op! of anders...
dreiging/ gevaar
PRIORITEIT maken
BOM die afgaat
Hoe kan je een productgebruiker motiveren nu een onderhoudshandeling uit te voeren?
zwaailichten
het product werkt met goed/optmaal
Of juist promotie / beloning
Je krijgt 10 eur als je NU dit doet!
of chocola of ...
de gebruiker iets nieuws laten ontdekken
nieuwe resultaten
iets gratis weggeven

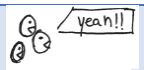

deurhanger
Voordeeltje
kunstwerk
Kunstwerk met kleine plaatjes
ACTIEKAART
Vinkje zetten
Info na 3 mnd weg opnieuw vinkje nodig


transparant product
Flashcards Spel - kunstje!
Memory

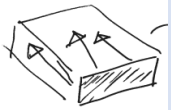
F.iii Results

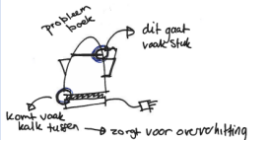
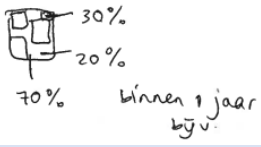
1	Hoe kan je een productgebruiker motiveren nu een onderhoudstaak uit te voeren?		Persoonlijke opmerkingen
a	Trillen		Voelbaar
b	Lampjes, flikkerende lichten		Zichtbaarheid
c	Toeter, bom die afgaat		Hoorbaar
d	Schiet op of anders… dreiging, gevaar		Expectancy-value-**cost**
e	Het product werkt niet goed/optimaal		
f	Iets gratis weggeven, beloning, geld, chocola		Extrinsieke motivatie
g	De gebruiker iets nieuws laten ontdekken		

2	Hoe kan je een productgebruiker informatie laten onthouden op het juiste moment?		Persoonlijke opmerkingen
a	“hallo! Vergeet niet… ik zie dat je … doet		
b	Meldingen telefoon		Digital interface
c	emails/nieuwsbrief		Digital interface
d	AI/siri		Digital interface
e	Flashcards in broekzak, ten alle tijde bij zich		
f	‘tentamen’/toets leren -> dan reproduceren kennis		
g	Herhaling van informatie		
h	agendaplanning		
i	‘trek een kaart’ onthoud		Spelelement, memory cards
j	Anders framen -> product heeft aandacht nodig -> mag in bad		Niet vervelend, maar leuk
k	Opdracht erbij geven waar de informatie nodig is		

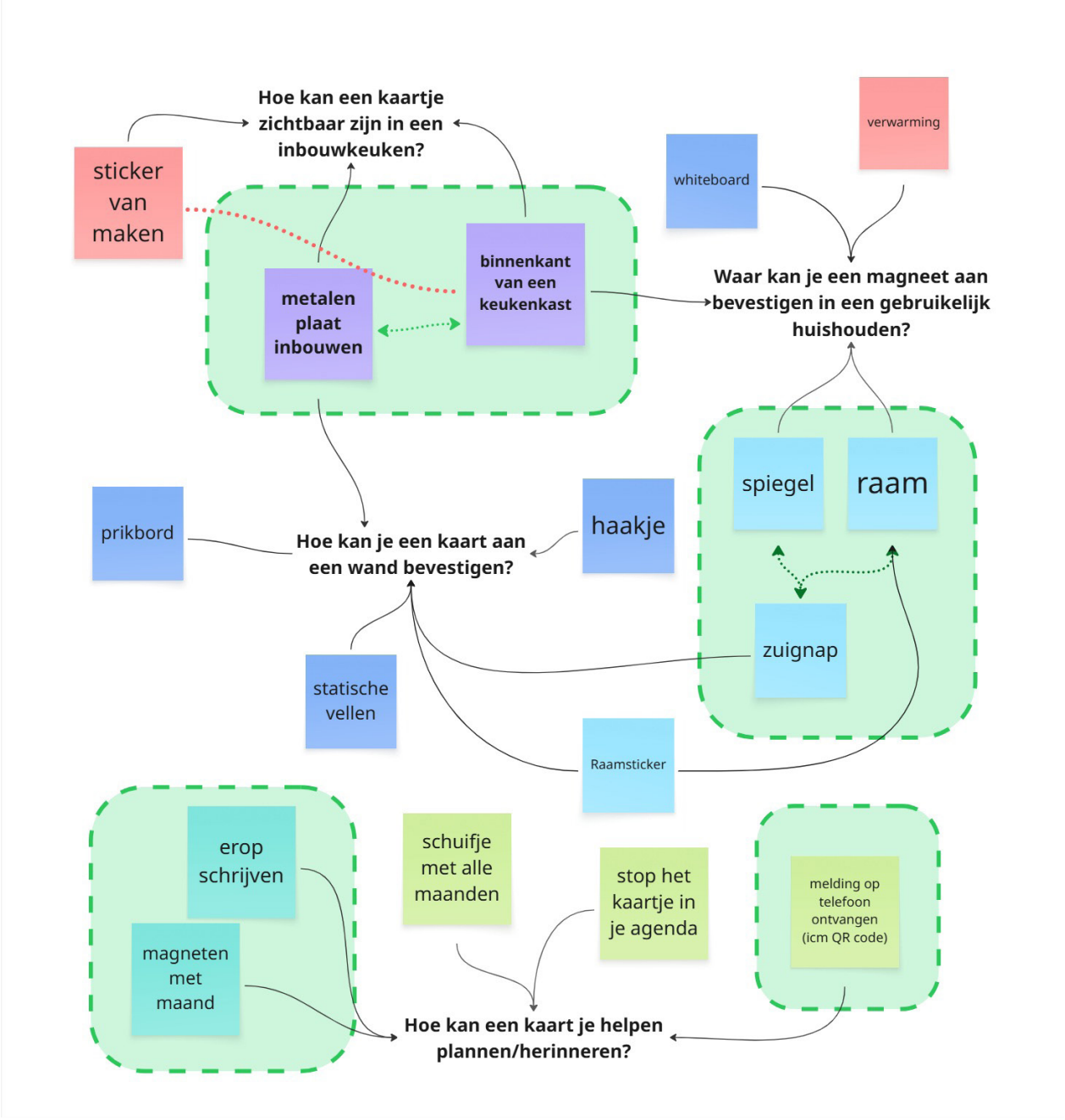
3	Hoe kan je een vervelende onderhoudstaak op een positieve manier bij de productgebruiker brengen?		Persoonlijke opmerkingen
a	Toejuichen! Whoop whoop, lekker Sam (framing)		
b	Schouderklopje, waar je daarna denkt, ja dat wil ik weer		
c	Massagebon of koffie		
d	To do list afvinken! Heerlijk gevoel.		
e	Positive reinformcement, complimenten geven		
f	Gamification -> bom die afgaat/beloning zoals punten sparen		

g	Combineren met een hobby of passie (muziekweetjes, koffienerds)		
h	App plant in leven houden, dan product		Digital interface
i	Lange termijn resultaat benadrukken		

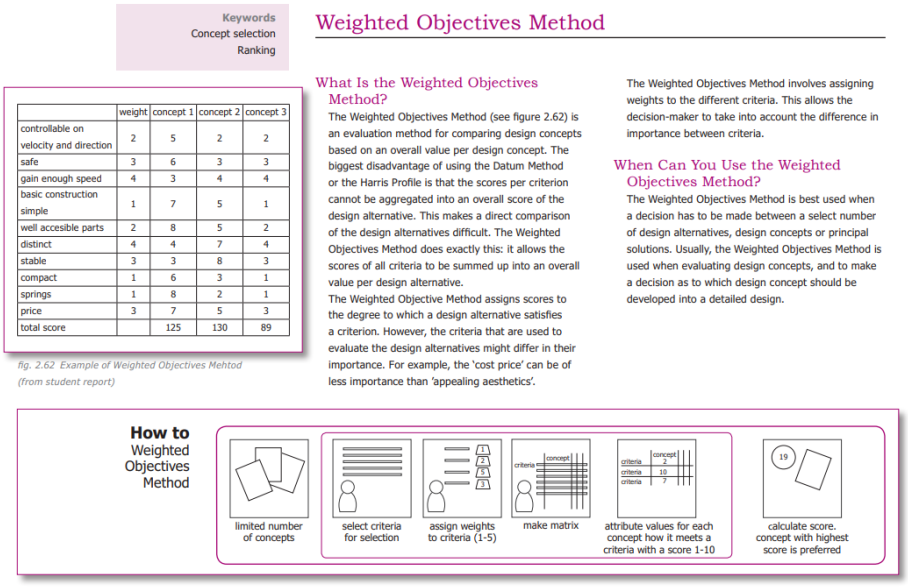
4	**Hoe kan je een productonderdeel (wat onderhoud nodig heeft) wat niet zichtbaar is, zichtbaar maken?**		**Persoonlijke opmerkingen**
a	AR-view, op een app		Digital interface
b	Hologram		
c	Transparante omhulsing		
d	Stickers aan de buitenkant vh product plakken van de niet-zichtbare onderdelen		
e	Licht laten geven		
f	Geluidssignaal afgeven		
g	Speciale bril		
h	UV-licht erop ‘geheimschrift’ opeens zichtbaar		

5	**Hoe kan je bewustwording creëren bij een productgebruiker?**		**Persoonlijke opmerkingen**
a	Confrontatie met onkunde		
b	Vragen stellen over de kennis die de persoon heeft		
c	Probleemboek\handboek met mogelijke problemen		
d	Flyer		
e	Soort thermometer ‘stukheidkans’		
f	Sensor-scan		
g	Knipperende lampjes		
h	Voorbeeldmodel in winkel		
i	Transparant demomodel		
j	Rating over onderhoudbaarheid		

F.iv Additional brainstorm Miro



G. Weighted Objectives Method



Keywords
Concept selection
Ranking

Weighted Objectives Method

	weight	concept 1	concept 2	concept 3
controllable on velocity and direction	2	5	2	2
safe	3	6	3	3
gain enough speed	4	3	4	4
basic construction simple	1	7	5	1
well accesible parts	2	8	5	2
distinct	4	4	7	4
stable	3	3	8	3
compact	1	6	3	1
springs	1	8	2	1
price	3	7	5	3
total score		125	130	89

fig. 2.62 Example of Weighted Objectives Mehtod (from student report)

What Is the Weighted Objectives Method?

The Weighted Objectives Method (see figure 2.62) is an evaluation method for comparing design concepts based on an overall value per design concept. The biggest disadvantage of using the Datum Method or the Harris Profile is that the scores per criterion cannot be aggregated into an overall score of the design alternative. This makes a direct comparison of the design alternatives difficult. The Weighted Objectives Method does exactly this: it allows the scores of all criteria to be summed up into an overall value per design alternative.
The Weighted Objective Method assigns scores to the degree to which a design alternative satisfies a criterion. However, the criteria that are used to evaluate the design alternatives might differ in their importance. For example, the 'cost price' can be of less importance than 'appealing aesthetics'.

The Weighted Objectives Method involves assigning weights to the different criteria. This allows the decision-maker to take into account the difference in importance between criteria.

When Can You Use the Weighted Objectives Method?

The Weighted Objectives Method is best used when a decision has to be made between a select number of design alternatives, design concepts or principal solutions. Usually, the Weighted Objectives Method is used when evaluating design concepts, and to make a decision as to which design concept should be developed into a detailed design.

Van Boeijen et al. (2013)

Weighted objectives

1. Visibility
2. Evocation of positive feelings towards maintenance or desire to avoid the negative consequences
3. Trigger awareness
4. Reminding of periodic maintenance
5. Timeless and/or personally satisfying appearance
6. Neutrality

	Weight
Visibility	25
Evocation of positive feelings towards maintenance or desire to avoid the negative consequences	20
Trigger awareness	20
Reminding of periodic maintenance	15
Timeless and/or personally satisfying appearance	10
Neutrality	10

Concept 1		**Concept 2**		**Concept 3**	
Score	*Total*	*Score*	*Total*	*Score*	*Total*
8	200	9	225	5	125
6	120	9	180	10	200
8	160	8	160	10	200
9	135	8	120	4	60
7	70	10	100	8	80
7	70	7	70	7	70
	755		855		735

H. AI image prompt examples

In this appendix, a few examples of AI *conversations* are depicted, which led to most of the images that are depicted on the final design. What was often done, was that the AI was asked to generate a descriptive prompt for an image in a specific style (according to the variant of the card), so that the prompt that was then generated could be adjusted accordingly. Often times, the first image that was generated was not completely suitable yet, therefore, based on the image that was generated, new input was given that ultimately did lead to the suitable images.

H.i Prompt example: variant *"Cheecky & Extreme"* broken washing machine with ChatGPT

Je zei: Write an image prompt for me. I want it to be a Comical absurdist drawing of a washing machine with coins and paperclips falling out, with scratches and loos parts and that has a scary and dramatic vibe

ChatGPT zei: Here's your image prompt:

"A comical yet absurdist drawing of an old, scratched washing machine with loose parts barely holding together. The machine is shaking violently, its door slightly ajar, as a chaotic stream of coins and paperclips spill out onto the floor. The scene has a dramatic, almost horror-like atmosphere—dark shadows stretch across the room, and the washing machine's control panel flickers ominously. A faint eerie glow seeps from the open drum, as if something unnatural lurks inside. The exaggerated, cartoonish details make the whole situation both hilarious and unsettling."

Je zei: A bit less scary

ChatGPT zei: Here's a revised version with a less scary vibe:

"A comical and absurdist drawing of an old, battered washing machine with scratches and loose parts wobbling dramatically. The door is slightly open, and a chaotic stream of coins and paperclips is tumbling out onto the floor. The machine looks overwhelmed, as if it's struggling to keep itself together. A few springs and bolts are popping out comically. The scene has a slightly dramatic but lighthearted atmosphere, with exaggerated cartoonish details—perhaps a few motion lines to show the shaking and some funny 'clunk' and 'clang' sound effects floating around."

Je zei: And now an image for this prompt: "A comical and absurdist drawing of an old, battered washing machine with scratches and loose parts wobbling dramatically. The door is slightly open, and a chaotic stream of coins and paperclips is tumbling out onto the floor. The machine looks overwhelmed, as if it's struggling to keep itself together. A few springs and bolts are popping out comically. The scene has a slightly dramatic but lighthearted atmosphere, with exaggerated cartoonish details—perhaps a few motion lines to show the shaking and some funny 'clunk' and 'clang' sound effects floating around."



1

ChatGPT zei: [see image 1] Here is your comical and absurdist drawing of the battered washing machine in chaos. Let me know if you'd like any changes!

Je zei: Improve the prompt for me. I want it to have eyes, like the absurdist animation of the washing machine you made me earlier this week

ChatGPT zei: Here's an improved version of your prompt incorporating eyes and an even more absurdist touch:

"A comical and absurdist drawing of an old, battered washing machine with big, cartoonish eyes on its control panel, looking panicked and overwhelmed. The machine wobbles dramatically, with scratches and loose parts barely holding it together. The door is slightly open, and a chaotic stream of coins and paperclips is spilling out onto the floor. A few springs and bolts are popping out comically, while motion lines emphasize its frantic shaking. The washing machine's expression is exaggerated—wide, worried eyes and a slightly open 'mouth' where the detergent drawer is, as if it's gasping. 'Clunk' and 'clang' sound effects float around, adding to the chaotic but lighthearted atmosphere."



2

Je zei: Now create the image

ChatGPT zei: [see image 2] Here is your absurdist, panicked washing machine with cartoonish eyes and a chaotic scene. Let me know if you'd like any refinements!

H.i Prompt example: variant *"Cheecky & Extreme"* dusty dryer with ChatGPT

Je zei: 'Can you make a prompt for a drawing, stylistically like the last one of the washing machine, but now of a washing dryer, with the fluff filter sticking out, being quite dirty, with a bunch of dirty fluff coming out'

ChatGPT zei: 'Sure! Here's a detailed prompt for your drawing request:

"A comical, animation-style drawing of a washing dryer in the same whimsical, absurdist style as the last washing machine image. The dryer has exaggerated, cartoonish features, including large, expressive eyes with a mildly concerned or embarrassed expression. The fluff filter is sticking out messily, packed with dirt and lint, with clumps of dirty fluff spilling out dramatically. The fluff appears exaggerated and textured, almost like a chaotic cloud of dust and fibers. The background is a simple, slightly dim laundry room, keeping the focus on the dryer's humorous and messy situation. The colors are vibrant yet slightly muted, with detailed shading and texture to emphasize the grime and the absurdity of the scene."

This keeps the style consistent while focusing on the messy, exaggerated look of the dirty fluff filter. Let me know if you'd like any refinements!'

Je zei: 'I want to make sure that the fluff filter is very clearly visible'

ChatGPT: 'Here's a refined prompt to ensure the fluff filter is clearly visible: "A comical, animation-style drawing of a washing dryer in the same whimsical, absurdist style as the previous washing machine images. The dryer has exaggerated, cartoonish features, including large, expressive eyes with a mildly concerned or embarrassed expression. The fluff filter is prominently sticking out in a dramatic way, placed at the forefront of the image to make it unmistakably visible. It is packed with dirty lint and fluff, which is overflowing and spilling onto the floor in exaggerated, chaotic clumps. The fluff appears textured, with strands and dust clouds adding to the messy effect. The background is a simple, dimly lit laundry room, ensuring the dryer and its messy filter remain the focal point. The colors are vibrant yet slightly muted, with detailed shading and texture to enhance the absurd and humorous nature of the scene."

This ensures the fluff filter is the centerpiece of the composition while keeping the same quirky, humorous style. Let me know if you'd like any further tweaks!'

Prompt: 'Thanks, now make the image of this prompt'

ChatGPT: 'Here's your comical animation-style drawing of a washing dryer with an exaggeratedly messy fluff filter. Let me know if you'd like any modifications!' [see image 1]

Prompt: 'Just a bit less fluff, but more dirty and the eyes need to have a more anxious look'

ChatGPT: 'Here's the updated version with less fluff, a dirtier appearance, and a more anxious expression on the dryer's eyes. Let me know if you'd like any more adjustments!' [see image 2]

Prompt: 'This image has two doors, it should have only 1 door, a bit less fluff inside of the machine but other than that its perfect'

ChatGPT: 'Here's the updated version with a single door and slightly less fluff inside the machine while keeping the anxious expression and dirty details. Let me know if you need any more refinements!' [see image 3]

Prompt: 'I want you to write a prompt for me for a drawing. I really liked the first to last picture you generated, but a washing dryer does not have two doors, so I need you to change that. I also want it to look like the washing dryer is almost sort of choking on the fluff. The fluff also can be mixed with dust and air'

ChatGPT: 'Here's a refined prompt based on your preferences:

"A comical, animation-style drawing of a washing dryer in a whimsical, absurdist style. The dryer has exaggerated, cartoonish features, including large, expressive eyes with a panicked, choking expression as it struggles with an overwhelming amount of fluff. The machine has a single door, clearly visible at the front. The fluff filter is sticking out dramatically, packed with a mix of dirty lint, dust, and air, creating a cloudy, chaotic effect around the dryer. Some of the fluff spills onto the floor, while other bits float in the air, emphasizing the dryer's struggle. The background is a simple, dimly lit laundry room, ensuring focus remains on the distressed dryer. The colors are slightly muted yet vibrant enough to enhance the humor and absurdity, with detailed shading and textures to bring out the grime and fluff-filled atmosphere."

This should perfectly capture the idea of the dryer "choking" on the fluff while keeping the style consistent with the previous images. Let me know if you'd like any refinements!'

Prompt: 'Make sure the eyes look anxious like the the next to last image'

ChatGPT zei: ‘‘Here’s a refined prompt ensuring the anxious eyes and the choking effect are clear:

"A comical, animation-style drawing of a washing dryer in a whimsical, absurdist style. The dryer has exaggerated, cartoonish features, including large, expressive eyes with an anxious, distressed expression, similar to the next-to-last image. The machine has a single door, clearly visible at the front. The fluff filter is dramatically sticking out, packed with a mix of dirty lint, dust, and air. The dryer appears to be choking on the fluff, with lint and dust bursting out of the filter and floating around like a chaotic cloud. Some fluff is spilling onto the floor, adding to the mess. The background is a simple, dimly lit laundry room, ensuring the focus remains on the distressed dryer. The colors are slightly muted but still vibrant enough to enhance the humor and absurdity, with detailed shading and textures emphasizing the grime and fluff-filled atmosphere."

This keeps the anxious expression while adding the choking effect with floating dust and fluff. Let me know if you’d like any further refinements!’

Prompt: ‘I have a question. What do you think the fluff filter is?’

ChatGPT: ‘The fluff filter (also called a lint filter) is a component in a washing dryer that catches lint, dust, and fabric fibers shed from clothes during the drying process. It’s usually a removable mesh or screen, located near the dryer door or inside the drum. It helps prevent lint buildup in the dryer’s vent system, reducing fire risks and improving efficiency.

In the context of your drawing request, the fluff filter would be sticking out of the dryer, overflowing with dirty, clumped-up lint, mixed with dust and air, making it look like the dryer is "choking" on it. Let me know if you were referring to a different part!’

Prompt: ‘Where is it located on a regular washing dryer?’

ChatGPT: ‘On a regular washing dryer, the fluff (lint) filter is typically located in one of the following places:

1. Inside the door opening – This is the most common location. When you open the dryer door, the filter is usually at the bottom edge of the opening. It can be pulled out to remove accumulated lint.
2. On top of the dryer – Some models have a lint filter in a pull-out compartment on the top panel of the machine.
3. Inside the drum (rear or front wall) – A few dryers have the filter placed at the back or front wall of the drum, requiring you to reach inside to clean it.
4. Behind a small lower panel – Some machines, especially washer-dryer combos, have a secondary filter hidden behind a panel near the bottom of the machine.

Since you're designing a comical drawing, you may want to exaggerate the location, making the filter stick out more dramatically than it would in real life. Would you like the filter placed in a specific location for better visibility in the drawing?’

Prompt: ‘I want for the prompt that you wrote me, that you describe number one, as a location of the fluff filter. I want in the image that the filter is half way pulled out, the door of the dryer is open, so that you can see have of the pulled out filter’

ChatGPT: ‘Here’s the updated prompt with the specific fluff filter placement and visibility:

"A comical, animation-style drawing of a washing dryer in a whimsical, absurdist style. The dryer has exaggerated, cartoonish features, including large, expressive eyes with an anxious, distressed expression, similar to the next-to-last image. The machine has a single door, which is open, revealing the halfway-pulled-out fluff filter located at the bottom edge of the door opening—just like in a real dryer. The filter is packed with a mix of dirty lint, dust, and air, overflowing dramatically as if the dryer is choking on it. Fluff and dust particles are spilling onto the floor and floating in the air, emphasizing the chaotic and suffocating mess. The background is a simple, dimly lit laundry room, ensuring the focus remains on the distressed dryer. The colors are slightly muted but still vibrant enough to enhance the humor and absurdity, with detailed shading and textures emphasizing the grime and fluff-filled atmosphere."

This ensures the fluff filter is in a realistic yet exaggerated placement while maintaining the humor and anxiety in the scene. Let me know if you'd like any final refinements!’

Je zei: ‘Make this prompt into an image.

ChatGPT zei: ‘Here’s your comical animation-style drawing of the washing dryer, with the anxious expression and overflowing fluff filter as requested! Let me know if you’d like any adjustments.’ [see image 4]

Je zei: ‘Can you improve the prompt for me? I want the dryer to be less happy looking and make it somehow more clear that it is out of breath, choking on dust and fluff’

ChatGPT: ‘Here’s an improved version of your prompt, making the dryer look more exhausted and struggling for air:

"A comical, animation-style drawing of a washing dryer in a whimsical, absurdist style. The dryer has exaggerated, cartoonish features, including large, expressive eyes that look exhausted, strained, and panicked, with heavy eyelids and sweat drops to emphasize its struggle. The machine has a single door, which is open, revealing the halfway-pulled-out fluff filter located at the bottom edge of the door opening—just like in a real dryer. The filter is packed with a chaotic mix of dirty lint, dust, and air, overflowing dramatically as if the dryer is choking on it. The dryer's mouth is slightly open, gasping for air, with puffs of dust escaping from it, reinforcing the feeling that it is suffocating under the mess. Fluff and dust particles are spilling onto the floor and swirling in the air, forming a dense cloud around the machine. The background is a simple, dimly lit laundry room, ensuring the focus remains on the distressed, suffocating dryer. The colors are slightly muted but still vibrant enough to enhance the humor and absurdity, with detailed shading and textures emphasizing the grime, dust, and chaotic atmosphere."

This version makes it clearer that the dryer is out of breath, gasping, and truly struggling with the fluff. Let me know if you'd like any other refinements!'

Prompt: 'Now make it into an image'

ChatGPT: 'Here's the image based on your refined prompt! The dryer looks exhausted and struggling to breathe under all the fluff and dust. Let me know if you'd like any further adjustments!' [see image 5]

Prompt: 'I like it, but not the amount of sweat, it should have a more dry look, a few drops of sweat are good, but not this much'

ChatGPT: 'Here's the updated image with a drier look—only a few drops of sweat remain to emphasize the anxiety without making it look overly wet. Let me know if you need any more refinements!' [see image 6]

1



2



3



4



5



6



H.i Prompt examples: Washing machines for variant *"Strange & Comical"* with CGDream

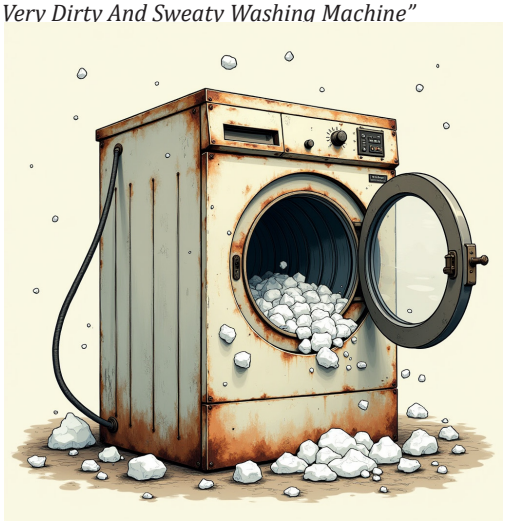
My Images | CGDream - Prompt: "Comical absurdist drawing of a rusty washing machine full of calcium"



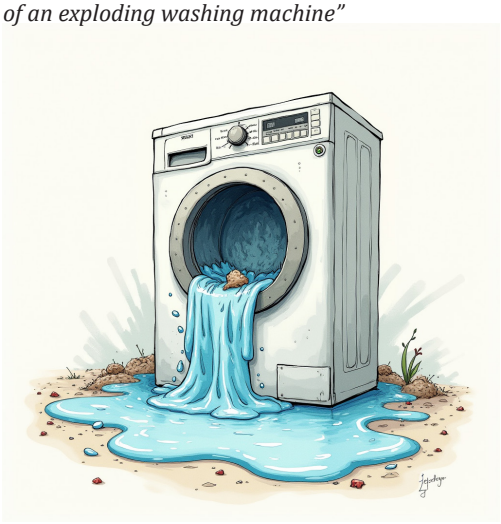
My Images | CGDream - Prompt: "Comical absurdist drawing of an leaking washing machine, overflowing with water and dirt"



My Images | CGDream - Prompt: "Comical Drawing Of A Very Dirty And Sweaty Washing Machine"



My Images | CGDream - Prompt: "Comical absurdist drawing of an exploding washing machine"



My Images | CGDream - Prompt: "Comical absurdist drawing of a washing machine, with dirty stinky clothes"



I. Validation: Focus group & feedback forms

I.i Participants information

Validation: participant information

Ptc.	**Age**	**Gender**	**Household**	**Income**	**Setting**
1	35	m	3 (of which 2 children)	Single income	Focus group session
2	30	w	2	Single income	
3	24	w	2		
4	25	w	2		
5	33	w	3 (of which 1 child)	Dual income	
6	20		>3	Dual income	Individually approached
7	20		3		
8	18		>3		
9	19		1		
10	19		1		

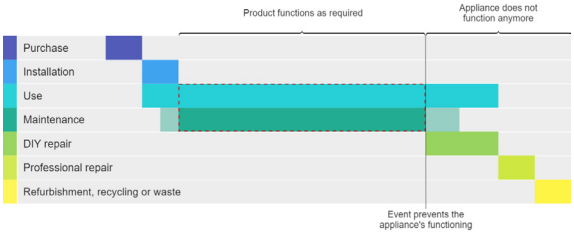
I.ii Feedback form templates

Focus group session

Questions part 1

Appliance maintenance is defined by Cambridge dictionary as: **"The work needed to keep an [appliance] in good condition"**

A product's life cycle knows many stages, some of which overlap with each other. For each stage, actions can be performed by the consumer to extend the product lifetime. This study focuses on the maintenance activities that a regular consumer can carry out in order to extend the period that the product functions as required, and to delay the occurrence of an event that prevents the appliance from functioning.



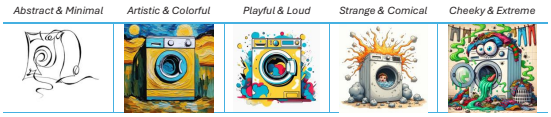
For this study, we're strictly focusing on the phase that the appliance functions as required and the maintenance behaviors that should/could occur during this phase and how to encourage behavior change towards better maintenance.

1. Name (optional): _____
2. Age: _____
3. Gender: _____
4. Household: _____
5. Household income:
   a. No income / student loan
   b. Single parttime income
   c. Single income
   d. Dual income
   e. Other: _____

6. What maintenance do you know to be necessary for the following appliances and how often do you do it?

	Maintenance type - multiple answers possible - include how often you think it should be done	**How often do you do it?** (leave blank if you do not own the appliance)
Washing machine		
Dryer		
Dishwasher		
(Microwave-) oven		

Follow-up questions



7. **How likely would it be that you would want one of these flashcard sets on your appliance?**

Not at all *Very much*

1 2 3 4 5 6 7 8 9 10

   a. **Why?**

_____

_____

8. **Which style would you most likely want in your house/on your appliances?**

_____

   b. **Why?**

_____

_____

_____

9. **Did you learn new things about necessary maintenance that you didn't know before?**

_____

_____

_____

10. **Do you have any other remarks?**

_____

_____

_____

Questionnaire for User Validation of the Magnetic Flashcard sets

This questionnaire is part of the master thesis research by Esther Meershoek. The aim of this questionnaire is to gain insight into the effects of the developed flashcards for electrical and electronic appliances (EEA) to encourage better maintenance of these devices. The data will be used for qualitative analysis, for example for anonymous citation in the reporting of the research.

☐ **I am aware that my answers in this form will be used for the above mentioned research purposes**

Age:_____

Household: ☐ Single ☐ Duo ☐ 3-person ☐ More than 3

Household income:

a. No income / student loan
b. Single parttime income
c. Single income
d. Dual income
e. Other:_____

1	2	3	4	5
Abstract & Minimal	**Artistic & Colorful**	**Playful & Loud**	**Strange & Comical**	**Cheeky & Extreme**
				

1. **How likely would it be that you would want one of these flashcard sets on your appliance?**

Not at all *Very much*

1 2 3 4 5 6 7 8 9 10

a. **Why?**

_____

_____

_____

_____

_____

2. **Which style would you most likely want in your house/on your appliances?**

_____

a. **Why?**

_____

_____

_____

_____

3. **Do you think you would remember what is on the back of the cards? Would you take a look at the back of the cards?**

_____

_____

_____

_____

4. **Do you think these cards will help with / improve your maintenance behaviors? Why (not)?**

_____

_____

_____

5. **Do you have any other remarks?**

_____

_____

_____

_____

_____

I.iii Tool explanation sheets

Tool explanation:

	What	How
Magnetic flashcards	Sets of 2-3 cards per appliance, with magnetic properties, which explain the use and maintenance operations that the appliance requires on the one hand, and on the other hand a slightly more artistic visualization of the appliance, so that the look can be chosen to match the interior.	The intention is that the cards are given to the customer/user when purchasing or instalment. By means of the magnetic property of the cards, they can be attached to the product itself or another product with a metal housing, as long as they are in a place that is regularly visible.

Goal: To bring awareness to the user about that their appliance requires maintenance, so that hopefully they will take preventive measures and perform the maintenance, but more importantly, even when they do not take action, when their appliance breaks down or starts showing signs of neglect, they will then have to acknowledge that it is due to their own lack of maintenance performed.

Photo examples:







Visual styles:

1	*2*	*3*	*4*	*5*
Abstract & Minimal	Artistic & Colorful	Playful & Loud	Strange & Comical	Cheeky & Extreme
				

Informed consent form for participation: EEA Maintenance Research

Research into behavioral factors concerning periodic maintenance of electrical and electronic appliances

This research is being carried out by Esther Meershoek of TU Delft, in collaboration with the Behavioural Insights Team of the Algemeen Strategisch Advies (ASA) department of the Ministry of Infrastructure and Water Management of the Netherlands.

The aim of this research is to gain insight into the effects of the developed flashcards for electrical and electronic appliances (EEA) to encourage better maintenance of these devices. The session will take about one hour. An audio recording could be made of the conversations. This audio will be transcribed to text file where the participant's names will not be recorded. The data will be used for qualitative analysis and for (anonymous) citation in the reporting of the research.

We do our best to keep your answers confidential. We minimize the risks by storing the digital data without names. The signed forms are stored separately from the audio and transcription files.

Your participation in this study is completely voluntary, and you can withdraw at any time without giving a reason. You are free not to answer questions. The anonymized data may be placed on the TU Delft repository at the end of the project, which serves as a platform for TU Delft's scientific output, in compliance with the Open Access principles.

For questions or comments, please contact Esther Meershoek

1. I have read and understood the information about the study. I had the opportunity to ask questions about the research and my questions were answered satisfactorily.

2. I am voluntarily participating in this study, and I understand that I can refuse to answer questions and withdraw from the study at any time, without having to give a reason.

3. I understand that my participation in the study means that the audio of the interview will be recorded and it will be transcribed.

4. I understand that my participation means that personally identifiable information and research data will be collected, with the risk that I may be identified from this.

5. I understand that within the General Data Protection Regulation (GDPR), some of this personally identifiable research data is considered sensitive, namely name, age, gender, income and email address.

6. I understand that personal information and this form are kept as secure as possible, and separately from each other. All this is to minimize the chance of a data breach and I understand that the personal information that is collected about me that can identify me is not shared outside the study team.

7. I understand that after the investigation, the anonymized information will be used for the final report and presentation.

8. I give permission to anonymously quote my answers, ideas or other contributions in resulting products.

9. I give permission for the data (without mentioning my name) that is collected about me to be archived in the TU Delft Repository so that it can be used for future research and education and I understand that access to this repository is open.

Name participant: Signature:

_____ _____







Kapotte wasmachine



Eerste Hulp Bij Onderhoud

Verkalkte wasmachine



Eerste Hulp Bij Onderhoud

Volgende onderhoud op:

88/88/88

Stinkende wasmachine



Eerste Hulp Bij Onderhoud

Volgende onderhoud op:

88/88/88

Kapotte wasmachine

1. Check altijd de zakken voor je kleding in de wasmachine doet.
2. Gebruik waszakjes voor BH's en andere items waar iets scherps zit dat misschien los kan komen.
3. Laat de wasmachinedeur en de wasmiddellade na een wasbeurt openstaan om zo schimmel te voorkomen.
4. Gebruik geen aggressieve reinigingsmiddelen. Deze kunnen de wasmachine beschadigen.

Eerste Hulp Bij Onderhoud

Verkalkte wasmachine

Draai elke 3 maanden een lege was op 90 graden ...

... met een goed geteste ontkalker of je kunt een vaatwastablet gebruiken ...

... zo voorkom je kalkaanslag en gaat je wasmachine jaren langer mee!

Eerste Hulp Bij Onderhoud

Stinkende wasmachine

Reinig maandelijks het filter en ...

... controleer de rubberen deurafdichting

... voor een schonere was en zo gaat je wasmachine langer mee!

Eerste Hulp Bij Onderhoud

1. Check altijd de zakken voor je kleding in de wasmachine doet.
2. Gebruik waszakjes voor BH's en andere items waar iets scherps zit dat misschien los kan komen.
3. Laat de wasmachinedeur en de wasmiddellade na een wasbeurt openstaan om zo schimmel te voorkomen.
4. Gebruik geen aggressieve reinigingsmiddelen. Deze kunnen de wasmachine beschadigen.

EERSTE HULP BIJ ONDERHOUD

Reinig maandelijks het filter en ...

... controleer de rubberen deurafdichting

... voor een schonere was en je wasmachine gaat jaren langer mee!

EERSTE HULP BIJ ONDERHOUD

Draai elke 3 maanden een lege was op 90 graden ...

... met een goed geteste ontkalker of je kunt een vaatwastablet gebruiken ...

... zo voorkom je kalkaanslag en gaat je wasmachine jaren langer mee!

EERSTE HULP BIJ ONDERHOUD

Eerste Hulp Bij Onderhoud



Eerste Hulp Bij Onderhoud



Volgende onderhoud op:

88/88/88

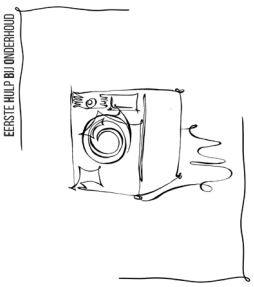
Eerste Hulp Bij Onderhoud



Volgende onderhoud op:

88/88/88

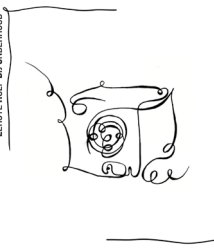
Kapotte wasmachine



geen zin in een kapotte wasmachine?

EERSTE HULP BIJ ONDERHOUD

Verkalkte wasmachine



Volgende onderhoud op:

88/88/88

EERSTE HULP BIJ ONDERHOUD

Stinkende wasmachine



Volgende onderhoud op:

88/88/88

EERSTE HULP BIJ ONDERHOUD

1. Check altijd de zakken voor je kleding in de wasmachine doet.
2. Gebruik waszakjes voor BH's en andere items waar iets scherps zit dat misschien los kan komen.
3. Laat de wasmachinedeur en de wasmiddellade na een wasbeurt openstaan om zo schimmel te voorkomen.
4. Gebruik geen aggressieve reinigingsmiddelen. Deze kunnen de wasmachine beschadigen.

EERSTE HULP BIJ ONDERHOUD

Reinig maandelijks het filter en ...

... controleer de rubberen deurafdichting

EERSTE HULP BIJ ONDERHOUD

... voor een schonere was en je wasmachine gaat jaren langer mee!

Draai elke 3 maanden een lege was op 90 graden ...

... met een goed geteste ontkalker of je kunt een vaatwastablet gebruiken ...

EERSTE HULP BIJ ONDERHOUD

... zo voorkom je kalkaanslag en gaat je wasmachine jaren langer mee!

1. Check altijd de zakken voor je kleding in de wasmachine doet.
2. Gebruik waszakjes voor BH's en andere items waar iets scherps zit dat misschien los kan komen.
3. Laat de wasmachinedeur en de wasmiddellade na een wasbeurt openstaan om zo schimmel te voorkomen.
4. Gebruik geen aggressieve reinigingsmiddelen. Deze kunnen de wasmachine beschadigen.

EERSTE HULP BIJ ONDERHOUD

Draai elke 3 maanden een lege was op 90 graden ...

... met een goed geteste ontkalker of je kunt een vaatwastablet gebruiken ...

EERSTE HULP BIJ ONDERHOUD

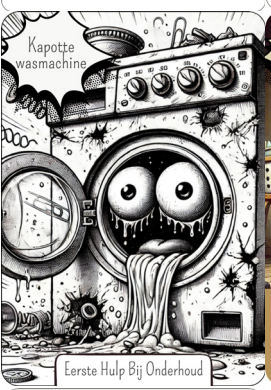
... zo voorkom je kalkaanslag en gaat je wasmachine jaren langer mee!

Reinig maandelijks het filter en ...

... controleer de rubberen deurafdichting

EERSTE HULP BIJ ONDERHOUD

... voor een schonere was en je wasmachine gaat jaren langer mee!







Stinkende oven



Eerste Hulp Bij Onderhoud

Volgende onderhoud op:

88/88/88

Vieze ovenplaten



Eerste Hulp Bij Onderhoud

Volgende onderhoud op:

88/88/88

Vieze ovendeur



Eerste Hulp Bij Onderhoud

Volgende onderhoud op:

88/88/88

Kapotte wasmachine

1. Check altijd de zakken voor je kleding in de wasmachine doet.
2. Gebruik waszakjes voor BH's en andere items waar iets scherps zit dat misschien los kan komen.
3. Laat de wasmachinedeur en de wasmiddellade na een wasbeurt openstaan om zo schimmel te voorkomen.
4. Gebruik geen aggressieve reinigingsmiddelen. Deze kunnen de wasmachine beschadigen.

Eerste Hulp Bij Onderhoud

Verkalkte wasmachine

Draai elke 3 maanden een lege was op 90 graden ...

... met een goed geteste ontkalker of je kunt een vaatwastablet gebruiken ...

... zo voorkom je kalkaanslag en gaat je wasmachine jaren langer mee!

Eerste Hulp Bij Onderhoud

Stinkende wasmachine

Reinig maandelijks het filter en ...

... controleer de rubberen deurafdichting

... voor een schonere was en je wasmachine gaat jaren langer mee!

Eerste Hulp Bij Onderhoud

Stinkende oven

1. Door de oven regelmatig schoon te maken, bijvoorbeeld **na elk gebruik of eens per week**, kun je ingebrande vlekken en aangekoekt vuil voorkomen.

2. Voor ingebrande vlekken kan je een ovenreiniger gebruiken of ...

... met de binnenkant van een doormidden gesneden citroen dep je de ingebrande vlekken in. Laat het inwerken.

Verwijder daarna het vuil voorzichtig met een vochtige of droge doek.

Eerste Hulp Bij Onderhoud

Vieze ovenplaten

De meeste ovenroosters zijn vaatwasserbestendig.

1. Kunnen jouw roosters niet in de vaatwasser? Laat ze weken in een warm sopje en verwijder hardnekkig vuil met een doekje of borstel.

2. Droog ze af voordat je ze terugplaatst in de oven.

3. Check vooraf de gebruiksaanwijzing hoe je het beste de ovenroosters kunt reinigen om beschadigingen te voorkomen.

Eerste Hulp Bij Onderhoud

Vieze ovendeur

1. Met een warm zeepsopje en een microvezeldoekje kan je de ovendeur schoonmaken.

2. Veeg de ruiten en deur schoon, laat het een tijdje weken als er hardnekkig vuil op zit, en neem het dan af met een zachte doek.

3. Bij sommige ovens kan de deur gedemonteerd worden om grondig te reinigen. Check de gebruiksaanwijzing of dit geldt voor jouw oven.

Eerste Hulp Bij Onderhoud