Design IoT Supported User Interventions for Sustainable Washing Usage



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Preface

This graduation thesis is the final deliverable of the Master graduation program Design for Interaction. It is also the outcome of my five-month journey of researching and designing the IoT supported interventions for a sustainable washing behavior stimulation together with HOMIE B.V.

I am using this opportunity to express my gratitude to everyone who supported me throughout my graduation project. It is your backing that makes the whole journey pleasant for me.

Firstly, I would like to thank my supervisor team, my chair Ruth Mugge and my mentor Emilia Ingemarsdotter. Thank you so much for your inspiring guidance and critical suggestions through my project, as well as keeping your door always open for me. I would also like to thank you both for the constant encouragement and stress relief. It is really a great experience to work with you.

Secondly, I would like to thank Colin Bom, my company mentor from HOMIE. Thank you for prompt responses to my questions all the time, supporting me with all kinds of resources and the regular insightful suggestions for my project. Special thanks to Nancy Bocken for your lasting interests in my project, your suggestions indeed showed me insights on an alternative perspective.

Additionally, I would like to thanks all the people who participated in my research and my test, especially Min from HOMIE. Without your kind help and rich input, I cannot imagine how I can finish the project.

Finally, to my parents, my dog, and my lovely friends, I sincerely thank you for your accompany, encouragement and support. It is knowing you will always be there that gives me the great courage to overcome whatever challenge I have met.

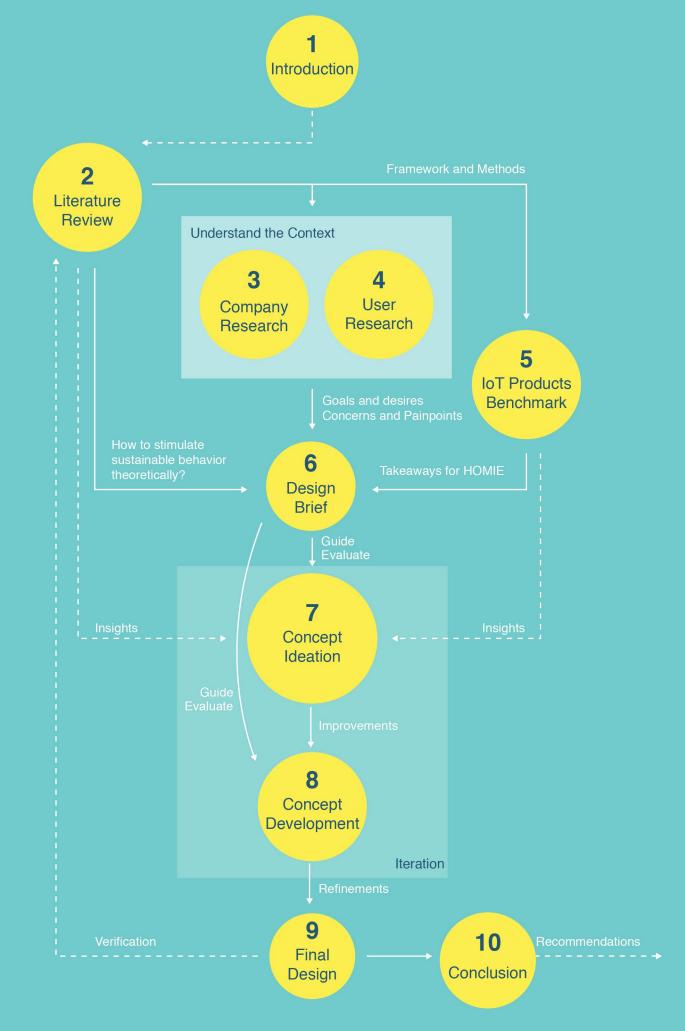


Figure 1: Project process

Executive Summary

Nowadays, the increasing populations and the higher demands of human's life are creating a high pressure on the environment. Laundry as a routine for all the families, requires a large number of resources especially with regards to its water and energy consumption. With the innovation in both the business model and IoT technology, HOMIE is currently working on making positive impact on the environment with their "Pay-per-use" smart washing machine. Even though the result shows it is effective, according to the research, users' behavior change could assist in saving even more resources. Therefore this project is established to explore the IoT supported interventions to stimulate sustainable user behavior in the washing process.

The main outcome of the project is a set of IoT supported interventions based on the washing machine, the machine interface and mobile application to influence users on decisions during the laundry process, to spur sustainable choices and foster sustainable washing habits.

This project is divided into 10 chapters, figure 1 shows the process.

Chapter 1 is the introduction of the whole project to explain the background of the project and HOMIE, the problem with the current situation and the main research questions.

Chapter 2 reviews literature in sustainable behavior change and the IoT smartness as well as capabilities, gives insights, methods, and frameworks to provide an understanding of the current situation and stimulate sustainable behavior in the theoretical aspect.

Chapter 3 is regarding the HOMIE company research together with Chapter 4 on user research is two sections to understand the current context. Chapter 3 dissects HOMIE's objectives and current interventions while chapter 4 elaborates on the goals, concerns, and desires for the user in the laundry activity and comprehension of sustainability.

Chapter 5 benchmarks washing machines, machine interfaces, and other IoT products to give inspiration on potentials of HOMIE washing machine and the future interventions.

Chapter 6 synthesizes the insights from previous chapters and defines the goals, targeted users and requirements for the future design.

Chapter 7 and Chapter 8 are the concept ideation and iteration in which initial concepts are refined and developed into the final concept: HOMIE Lifestyle by fast prototyping and two formal user testing.

Chapter 9 demonstrates the final design of HOMIE Lifestyle for two personas, "Greene" and "Eva" in different user flows under diverse contexts.

Chapter 10 reflects on the whole process of the project and gives suggestions for the future research.

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Introduction

- 1.1 Background and Context
- 1.2 Problem Definition
- 1.3 Research Questions and Approach

1.1 Background and Context

The increase in global population and the increased pressure on natural resources are creating a growing need for sustainable development. Sustainable initiatives solely focused on the supply-side can be inadequate on their own, and excessive consumption patterns also need to be tackled in order to create an effective sustainable development (Bocken & Short, 2016). Therefore there is a need to reconsider the product in a sustainable context.

Laundry is an important routine activity performed in private households. It is an resources consuming activity since water and energy usage are inextricably linked in laundry operations. Pakula and Stamminger (2009) estimated that the worldwide resource consumption for laundry washing by washing machine sums up to about 100 TWh of electricity and 20 km3 of water. Thus the laundry sustainability is worthy of a research.

HOMIE is a spin-off of TU Delft which focuses on reducing the environmental impact of domestic appliances and offering more affordable solutions to customers, by moving from "ownership" to "Pay-Per-Use". The main product they are running now is the washing machine. With the pay-per-use business model, no cost is asked for the purchase, installation and the repairment, with customers only paying per wash. Their pricing scheme stimulates user's washing behavior to choose a lower temperatures washing and eco-washing mode. Consequently from the research, the business model in general already changes people's behavior (Bocken, 2017)

Although the "pay-per-use" business model has a positive impact on the environment, the positive environmental effect can be heighten if the user behaves more sustainably. A study researching potential savings if both technology and user's behavior is changed towards better practices (full capacity and use of low temperatures) shows that it is possible to save up to 50% of both energy and water, which means more than 12TWh of electricity and about 870 million m3 of water (Pakula & Stamminger, 2015).

The interface of the washing machine, which is the main touchpoint during the laundry process plays an important role in providing feedback information and guiding user's behaviors. However, HOMIE has not adjusted it to influence user's behavior presently.

Looking at the next step of the HOMIE pay-per-use business model and a more positive impact on the environment, this project aimed to explore new user interventions on the washing machine interface which can be designed to encourage users to behave more sustainably and actively engage the system.

1.2 Problem Definition

HOMIE has already implemented some user interventions such as monthly usage email sent to users however the previous research found that those interventions have little impact on changing users' behaviors (Wortel, 2017).

Hence this project focuses on exploring new user interventions to stimulate sustainable user behavior in the washing interactions, testing them rapidly and iteratively in the real context to reach the next step for the pay-per-use business model.

To differentiate from the former research that considered the whole washing process, user's interactions with the washing machine and the washing machine interface will be the focus areas in this project. Additionally, this project will take the smartness of IoT into account to explore new possibilities for the interventions.

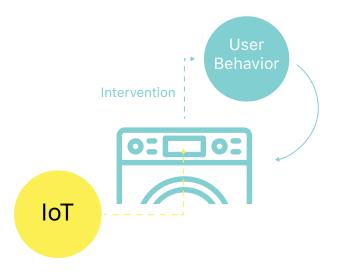


Figure 2: Problem definition

1.3 Research Questions and Approach

The main research questions with specific subquestions are as follows:

 What are HOMIE's expectations and possibilities regarding the sustainable intervention?

How does the pay-per-use business model work in sustainable behavior stimulation?
What are HOMIE's desires for the intervention?
What interventions did HOMIE try before?
What sustainable intervention strategies can HOMIE learn from other brands?

 What are the users' behavior patterns when they interact with the washing machine?

What are users' concerns and expectations during the washing procedure?

How do they understand the sustainable washing? What can trigger them to behave more sustainably?

 What IoT supported user interventions can HOMIE use to stimulate sustainable usage?

How could loT contribute to the sustainable behavior changing?

How do interventions influence users in encouraging them to behave more sustainably? How to foster the user's sustainable washing habit?

Multiple types of research (Figure 3) and tests will be needed to answer research questions:

- User research including interviews and data analysis to understand user motivations, frustrations and attitudes toward a sustainable washing.
- Literature review to guide on sustainable behavior change, opportunities of the pay-per-use business model and IoT strategies.
- Company research and benchmark to explore HOMIE's opportunities and potential future solutions.
- Rapid prototyping and user test to evaluate different user interventions.









Figure 3: Research methods

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Literature Review

This chapter aims to provide an overview of the existing literature that is relevant to this project. The goal of the literature review is to first ascertain the frameworks and methods to study the current context, then find out how to stimulate sustainable behavior theoretically. Two main parts are discussed:

The first part containing chapter 2.1 is the literature of Fogg's behavior change model and behavior change dimensions to create motivations for the user. In this part, the strategies of designing sustainable interventions are discussed to provide the understanding of what strategies can be implemented to achieve sustainable washing.

Chapter 2.2 focuses on IoT capabilities and smartness, and their potentials on sustainable behavior changing.

2.1 Behavior Change Models

2.2 IoT Capabilities and Sustainable Strategies

2.1 Behavior Change Models

HOMIE is now supplying their washing machines under the "Pay-Per-Use" business model, which is a sufficiency-based business model, where companies offer their customers functionality rather than the ownership of products (Bocken et al., 2014). With the pay-per-use business model, the environmental impact reduction potential is shown(Tukker, 2004). In HOMIE case, it proves that the business model in general already changes people's behavior(Bocken, 2017). However, according to a research, if both technology and user's behavior is changed towards better practices, more energy and water can be saved(Pakula & Stamminger, 2015). The former practice of HOMIE relies more on the business model and strategy level, therefore there is a need for intervening user's behavior to a more sustainable level.

Fogg Behavior Change Model and Dimensions

Fogg (2003) proposes a behavior change model, in which he distinguishes three elements: Motivation, Ability and Triggers that need to converge at the same time for people to show a certain behavior.

People can be motivated by getting a good experience from the act of doing the behavior itself or from experiencing the results of showing the behavior, like through the sense of accomplishment or rewards. Motivations can be intrinsic and extrinsic. Intrinsic motivation refers to doing something because it is inherently interesting or enjoyable while extrinsic motivation refers to doing something because it leads to a separable outcome (Ryan & Deci, 2000). Virtually every type of expected tangible reward made contingent on task performance, in fact, undermine intrinsic motivation. Furthermore, not only tangible rewards, but also threats, deadlines, directives, and competition pressure diminish intrinsic motivation. Extrinsic motivation can be used as a boost to get going, but in the long run, intrinsic motivation works better (Ryan & Deci, 2000). Therefore, the intervention design can start from building extrinsic motivations such as incentives or punishments for users. Thereafter, it will be necessary to build the intrinsic motivations for the sake of a long-term user engagement.

Ability describes the capacity for people to show the behavior at the given moment and in the given context. Triggers remind users to initiate certain action, also facilitating the behavior. Although triggers are functional in activating a certain behavior, this only works if there are enough motivation and the ability to show the behavior (Figure #). Therefore, the intervention which also aims at changing behavior should not only motivate the user but also should be easy for the user to operate. Daae and Boks (2014) categorized nine dimensions for behavior change, one of them is Meaning, which motivates the user through hedonic or rational purpose. Thorpe (2010) suggests that design can help by creating meaning for users to influence the consumption of goods and user behavior. Therefore, creating the rationale by design for the user is a way of creating motivations. When the motivation is high, the behavior change happens more easily.

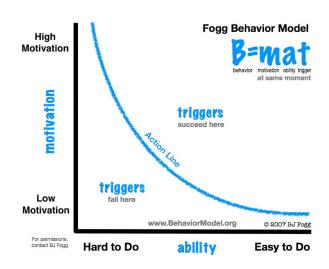


Figure 4: Fogg behavior change model

Sustianability in Washing Process

In order to design the intervention for improving the sustainability during the laundry process, it's essential to understand what does sustainability mean in the process. There are five key drivers for reducing the environmental impact of washing:(Bourrier at al., 2011) (Koerner et al., 2011)

- Increase washing load
- Decrease the washing times
- Lower temperature
- Decrease the detergent
- Making optimal use of the machine's parts (through sharing, proper maintenance and recycling)

These drivers address the direct influence on the environment in energy, water consumption and waste generation. Hence, in order to design the sustainable intervention, these drivers can be seen as goals to achieve.

Sustainable Design Interventions Strategies

Multiple models have been developed for facilitating sustainable behavior change in the last decades. Earlier research by Mansouri et al. (1996) showed that users would reduce the energy consumption in general if they are provided with information about how to reduce the energy consumption of appliances. More recently, from research in the field of sustainable design or design for sustainability, several authors have built on these notions to develop sustainable design strategies that influence the consumer at different levels (e.g., Bhamra et al., 2008; 2011; Tang, 2010; Wever et al., 2008). Lilley (2005) proposes three interventions: Eco-feedback, Behavior steering and 'Intelligent' Products and Systems, for promoting sustainable behavior during the use phase which does not completely rely on users consent and does not require them to be committed with sustainability.

While certain behaviors remain stable, habits have a strong influence on consumer behavior. A habit happens when a specific situation triggers a specific response (Jager, 2003). Anderson (1982) identifies three stages in the formation of a new habit: the declarative stage, the knowledge compilation stage and final procedural stage. In the declarative stage, the habit is mainly influenced by factors like attitudes, norms, rules and emotions. In the knowledge compilation stage, the practice plays a more important role in the habit formation and in the procedural stage, the habit is already formed. During the process of habit formation, the automaticity that is built up during this process creates increased efficiency in the behavior. A lack of awareness, makes the behavior less intentional

and less controllable from the part of the consumer(Lally et al., 2010).

As an expansion of Lilley's model, the Design Behavior Intervention Model (DBIM) (Tang, 2010)(Figure #) proposes seven strategies which are more complete in the sustainable consumption context relating with the habit model as well as behavior models.

On the left, 3 elements of behavior change: intention, habits and control are shown. On the right, 7 sustainable design intervention strategies are shown on the right of the model to create sustainable user behavior: (Tang, 2010)

- Eco-information: providing the user information and insight into the environmental impact of their behavior in order to help them reduce it.
- Eco-choice: providing the user with clear options of how they could reduce their environmental impact
- Eco-feedback: motivating the user towards environmentally and socially responsible behavior by offering real-time feedback
- Eco-spur: guiding the user towards more sustainable behaviour by rewarding sustainable behaviour and punishing unsustainable behavior
- Eco-steer: using constraints in the product design to guide the user towards sustainable behavior
- Eco-technology: using technology to persuade and control the user behavior automatically
- Clever design: without focusing on the user's awareness or decision making, make the user act sustainably automatically through the design of the product

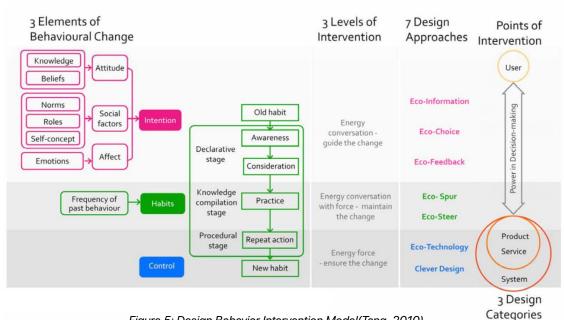


Figure 5: Design Behavior Intervention Model (Tang., 2010)

These strategies range from the user to the product and service in the decision making power. According to the state of behavior change: the interventions aimed at user-led decision making are linked to the declarative stage of habit forming, since the user's intentions have a large influence on their behaviour in that phase (Jager, 2003), whereas the interventions aimed at product/service led decision making are linked to the stages where the habit is already formed: the knowledge compilation phase and the procedural phase (Tang, 2010).

Because user's behavior in later habit formation phases is largely influenced by existing habits (Jager, 2003), influencing the user's intentions is not enough to create the new sustainable behavior. Therefore, the Ecospur and Eco-steer strategies link directly to the habits change may be more successful in altering the user behavior. However the user's acceptance maybe low because it somehow force behavior to ensure the change happen (Bhamara et al., 2011). Thus the intervention design should be careful in user experience and outcome of the desired habit should be reinforced to stimulate the user to accept.

The Eco-technology and Clever design have the potential to tackle some of the steering and feedback strategies disadvantages, however it may result in some new concerns since it is forcing the change(Tang, 2010). Wever et al. (2008) argue that intelligent products which circumvent the user's decision- making process, adapting automatically to changing circumstances, or designing-in strong obstacles to prevent unsustainable behaviour, would have to be designed very carefully from a usability perspective. Considering the concerns of all strategies, new products need to be prototyped and user-tested carefully to evaluate their effectiveness and social and ethical considerations (Bhamra et al., 2011).

2.2 IoT Capabilities and Sustainable Strategies

IoT Capabilities

loT which means Internet of Things, is a fast developing area which no unified definition is given yet. According to the research, Kees, Oberlaender, Roeglinger and Rosemann (2015) gives a definition: The connectivity of physical object (things), equipped with sensors, and actuators, to the internet via data communication technology, enabling interaction with and/or among these objects. A 'smart object' can be defined to have the ability to sense, interact and communicate with their environment (Korteum et al. 2010).

Data recorded by sensors of products' performance, can support a better service. The capabilities of connected products can be grouped into four areas: Monitoring, Control, Optimization and Autonomy (Porter & Heppelmann, 2014) (Figure 6)

In the monitoring level, the performance of products is given as a feedback to user for further actions. In the control level, smart products can allow users to control their own systems remotely, or let the service providers and/or the system itself exercise control without user involvement (Porter and Heppelman 2014). Optimization is about 'goal-based improvements' using algorithms which learn from historical user behavior (Porter and Heppelman 2014). Real-time monitoring of product conditions can also allow firms to optimize services by performing preventative maintenance when failure is imminent (Porter and Heppelman 2014). Autonomous products combine monitoring, control, and optimization capabilities to achieve a level of autonomy. Such products can interpret data, 'self-diagnose', and act accordingly. (Porter and Heppelman 2014).

			Automation
		Optimization	
	Control		
Monitoring			

Figure 6: IoT capabilities

Smartness and Sustainable Behavior Change

Smartness of products can support changes towards sustainable behavior, by creating decisions for users that may not be apparent, natural or habitual to them or proposing more accurate features according to the context and moment of use(Bocken, Ingemarsdotter & Gonzalez). Similar theory in the sustainable design interventions has been mentioned before: The 'Intelligent' Products and Systems by Lilley et al. (2005), contextbased by Lockton et al. (2008), forced functionality by Wever et al. (2008) and eco-technology and clever design by Tang, (2010), from where the potential of IoT to achieve sustainable behavior change can be seen. Linking back to the Design Behavior Intervention Model (DBIM) (Tang, 2010), it indicates that more product-lead interventions can influence on habit. In the IoT context it can be predicted that the smarter capabilities can better facilitate the sustainable behavior change.

The washing intervention research of Bourgeois et al. (2014) proves that smart capabilities work better on behavior change. It shows that feedback, delayed and real-time, is not an effective way of supporting demand shifting behavior in contrast with proactive suggestions which give the washing suggestion to the user in advance. Comparing to giving the feedback which deploys in the monitoring level, it relies on the optimization of IoT capability.

Smartness of objects plays a role in both opportunity and challenge in the behavior change which has been discussed before. If the smartness is overuse and forcing the user to change behavior, users would drop the product. Therefore, the design should be cautious and can combine with more user-centered decision-making strategies.

🥀 Key Insights



03

Company Research

This chapter focuses on HOMIE internal research. The aim of the company research is to understand HOMIE's business objectives, pay-per-use business model along with HOMIE's current sustainable interventions. The analysis is conducted to provide an overview of HOMIE's business, product, goals and improvements regarding the interventions.

- 3.1 HOMIE's Business Objectives
- 3.2 Business Model Analysis
- 3.3 Relationship with Machine Producer
- 3.4 Data Usage and Current HOMIE Interventions

3.1 HOMIE's Business Objectives

HOMIE was founded as an innovative spinoff from TU Delft in 2016. Starting from the washing machine, It operates the sustainable appliances concepts proposing, developing and testing within the Pay-Per-Use business model.

As an innovative spin-out contributing to the circular economy, HOMIE was founded with two main objectives:

- Making better appliances for the consumer world.
- Fostering sustainable consumer behavior of using white goods and creating positive impact on the environment

3.2 Business Model Analysis

This section will look into how HOMIE operates as a company, and explain the company's business model using Bocken et al.'s (2014) Business Model Framework. The pay-per-use business model of HOMIE is described in three aspects: value proposition, value creation and delivery, value capture.

Value Proposition

The value proposition is described by HOMIE product and service, customer segment and customer relationships.

For the product, HOMIE is now using washing machine: Zanussi ZWF71443W(Figure 7). This machine is of high quality with A+++ energy efficiency label. It has a maximum load for 7kg. However, it is only able to full load in the Cotton program where the cleanliness of clothes is

assured. For example in the woolen program, users can only load ½ of the volume to ensure the washing quality. If the users load too much clothes and it known by HOMIE, they will call the user to caution their usage. Otherwise it will be reported in the monthly email.

In figure 8 a picture of the washing machine user interface is shown. The button left is for choosing washing programs. The programs are classified by both material and clothes type. The Cotton Eco program is a special program for a sustainable washing, it only allows 40 degrees and 60 degrees washing with a longer washing time but less energy consumption compared to a common program. When users have chosen the program, the default temperature, the spin speed and the time needed are shown by indicating lights and the simple screen and users can adjust them. For the cotton mode, it takes 3h for washing in 30 degrees and 1400 spins. But for Eco mode, it takes 3h 43 mins for washing in 40 degrees with 1400 spin. In addition, there is another fast program called 30@30', which means wash 30 degrees for 30 mins. The Quick function is designed to reduce washing time as well, it can reduce up to 50% washing time for all the programs.

Additionally, the delay start function is also enabled for the washing machine, where users can set a maximum 20 hours delay for washing.

For the functions and the interface of HOMIE washing machine, although the interface is clear in settings, it is obvious that the sustainable information is still missing on the interface, and the Eco program should enable the cold wash and 30 degrees to make it real eco.



Figure 7: HOMIE washing machine



Figure 8: HOMIE washing machine interface

A tracker (Figure 9) which can record the washing usage is built inside the machine, when the machine is connected via WiFi, allowing the tracker to send the washing data to the server for both developers and consumers, and enabling the pay-per-use business model.

When new customers join HOMIE, HOMIE will plan an installation date and will deliver and install the washing machine for free. After the installation of the washing machine, the customer can start using the washing machine. After each wash the customer will receive a payment request via email for the washing programmes that have been used. Using PayPal or bank transactions, the customer transfers money to their HOMIE account, and with that credit they can pay for their washes. The whole service process is shown in figure 10:



Figure 9: Tracker in HOMIE washing machine

For the customer segment, HOMIE has identified four targeted user profiles:

Low income customers

Due to the resources limitation, this group seeks for cheaper products and service to support a better life. They will be attracted by the free installation, repair of the washing machine and the every time cost control.

Roamers

Roamers are the user group who lives a short time at a place. Instead of paying a lot for a machine that is used for a short time, the HOMIE pay-per-use washing machine offers a more flexible choice.

• Green Millennials

The green Millenials is a group of people who concern about environment and behaves in a sustainable manner.

Shared housing customers

In the shared houses, multiple users use one washing machine. In this situation, different users need different identity to wash and pay-per-use method can reduce some troubles.

Though there are four main types users, HOMIE wants to focus more on the private usage more so the low income, roamers and green Millenials are the key users in this case.

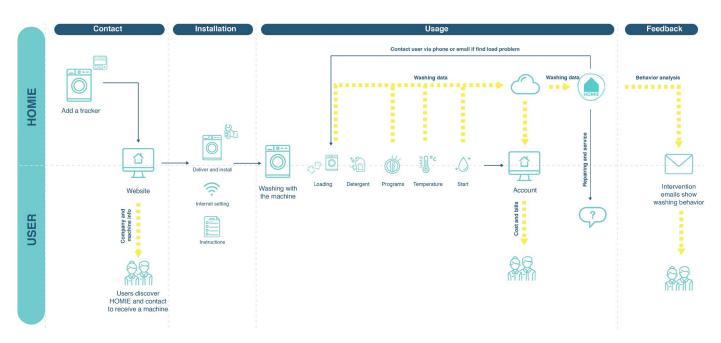


Figure 10: HOMIE current service process

Value Proposition

Three main value is created and conveyed to HOMIE customers through their products and services as follows(Gonzalez, 2017):

- Affordability. The pay-per-use business model enables the value since customers only pay for their wash. No other fees are needed.
- Worry-free is related with installation, maintenance and replacement for free as well as the certainty that there are no hidden fees.
- Environmental friendliness is approached from the circularity of the product, replacement of old washing machines with energy efficient ones and through monthly feedback and suggestions that promote a more efficient washing machine use.

As for the technology aspect, the tracker inside the washing machine can collect washing data. The data is first saved locally and then sent to HOMIE's server. When the wash starts, it is immediately reflected in the webpage, visible for both company and user. If the washing machine is offline, users can still use it to wash while data saves locally, therefore, no updates of bills and data on the webpage. When it's online again, all data will be uploaded. (Figure 11)

Through the webpage, users can see Washing Date, Program, Temperature, Price and Payment Details. For the developers of HOMIE, when there is a washing happening, they can read the data of Wash ID, Machine

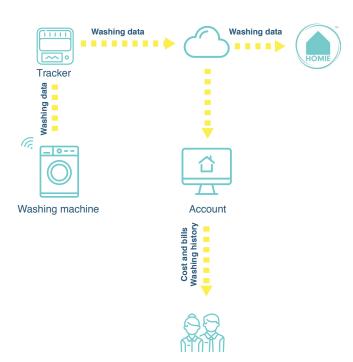


Figure 11: Data flows of HOMIE

number, Program, Temperature, Time the washing happened and the Time that data uploaded to the server at the backend of the system. (Figure 12)

Besides that, after each wash users automatically receive a payment request by email which leads them to the service portal, they can pay the bill with the credit card or Paypal. The collected data has value in tracking the usage and making tailored suggestions on better washing behavior for customers. Current interventions mostly focus on mailing which will be discussed in section 3.3.

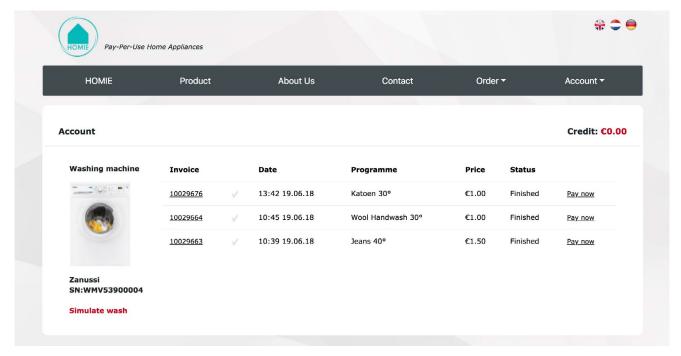


Figure 12: HOMIE webpage user account

Value Capture

With Pay-per-use business model, users only pay fee for each wash with an all-included price, it means that the cost of water and electricity is included. What's more, there are no hidden costs (e.g. deinstallation).

Since there is a significant difference in energy consumption between washing temperatures, the price varies accordingly to it. This is proposed as an incentive to reduce temperature and is a win-win for both the users by reducing cost and the environment by consuming less energy. In addition, the user can save 0.25 euro per wash when they choose to use the Eco mode. The price scheme is as follows:

- A cold wash costs €0,75 (incl. VAT)
- A 30°C wash costs €1,00 (incl. VAT)
- A 40°C wash costs €1,50 (incl. VAT)
- A 60°C wash costs €2,00 (incl. VAT)
- A 90°C wash costs €2,50 (incl. VAT)

The use of the machine's drain and spin programmes is free.

3.3 Relationship with Machine Producer

The producer of HOMIE washing machine, Gorenje, is a Slovenian white goods manufacturer based in Velenje, Slovenia(Wikipedia). They will probably build their new Pay-Per-Use washing machine model based on their current washing machine line, combined with a new user app to control the appliance.

Their latest washing machine model is ASKO W4086C.W (Figure 13,14), this washing machine has a tiny interface with highly responsive touch-sensitive buttons as well as a convenient rotary knob. Although the interface is limited in size, all programmes can be combined and adjusted to personal needs with the mode function.(asko.com, 2018) However, similar to the current HOMIE washing machine, it has not implemented sustainable interventions on the interface yet.



Figure 13: ASKO W4086C Washing machine



Figure 14: ASKO W4086C Washing machine interface

🔭 Key Insights

- HOMIE aims to reduce environmental impact and foster sustainable consumer behavior by using payper-use business model and intervention strategies
- The pay-per-use business model generally has positive impact on sustainable behavior change.
- The machine should improve the Eco program with more temperatures to choose, otherwise, the Eco mode is not convincing to be sustainable if only 40 and 60 degrees are available.
- Regarding this project, HOMIE wants to see how the user interface of the washing machine can be changed to enable real-time intervention since the sustainable information is missing on the current interface.

- The machine producer of HOMIE will be Gorenje, a Slovenian white goods manufacturer
- They will build the pay-per-use business model based on their current washing machine ASKO W4086C.W, whose interface is really tiny in size and has not put any sustainable intervention.
- The future concept design should focus on the nove idea, therefore, the concept should not be restricted by the screen size.

3.4 Data Usage and Current HOMIE Interventions

With the tracker inside the washing machine, HOMIE is able to collect the washing data from all users. Currently, HOMIE is using data in two aspects: the first one is to calculate the washing price. In this situation, the temperature is the only parameter for calculation. As mentioned before, each temperature directly links to a price and users can see this information on the webpage when they are going to pay.

The second usage of data is to track usage and provide feedback on changing users' behavior to make a more efficient and sustainable use. HOMIE has already made some efforts on testing different interventions for the user to the effects in fostering their sustainable habits by using data collected. At the end of each month, users will receive the intervention email from HOMIE with tailored contents(Gonzalez, 2017):



The intervention emails can be found in Appendix 2

- First month: Washing consumption including programs used, temperature, time of the day, total energy and water consumption. Suggestions on how to behave better.
- Second month: Comparison of the previous month usage, also suggestions.
- Third month: Comparison of two previous months programs and social comparison with average Dutch household. In addition, tailored suggestions are provided.

- Fourth month: Social comparison. Starting from this month, users can set a goal of sustainable washing for the coming months.
- Fifth month: Most used programmes until the point of time.

The email contents come from the analysis of user's washing data. In this situation, temperature, time of the day, energy and water consumption are shown with diagrams to give users an overview.

Analysis of the 21 HOMIE customer samples shows the result that the pay-per-use business model coupled with a free month following the introduction of "pay-per-use", providing information, and social comparisons can help improve sustainable behavior patterns (Bocken et al., 2018). However, there are no significant different effects that to be seen on different interventions (Wortel, 2017). Therefore, HOMIE has changed the interventions from March 2018 to a standard monthly intervention mail which is the same in the content structure for all customers. (Figure 15)

The new version HOMIE intervention email primarily consists of washing behavior in the past month, displays in 4 diagrams: Numbers of washes and wash temperatures, Programs, Energy consumption of the user and average Dutch usage, Water consumption of the user and average Dutch usage are shown in the 6 months time span for users.

Referring to the sustainable behavior strategies (Tang, 2010), the new version interventions including emails and value capture cover two levels: Eco-information and Eco-spur. (Table 1)

Level	HOMIE Intervention Email
Eco-information	Personal consumption in washing times, temperatures, programs, energy and water. Personal consumption comparison of 6 month Social comparison with average NL usage of the same type user
Eco-spur	Price incentives

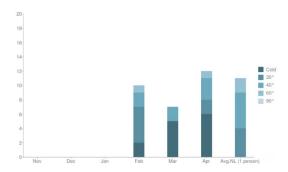
Table 1: HOMIE new monthly intervention email strategies analysis

2. Washing behaviour in the past month

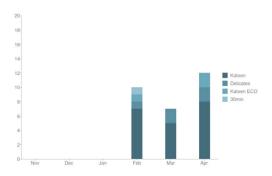
The following graphs provide you with information on your washing behaviour for the last few months.

of Washes & Wash Temperature:

Below you can see your total number of washes per month and a breakdown of wash cycle temperatures. For comparison we added a bar on the far right with the average for a Dutch household of 1 person.

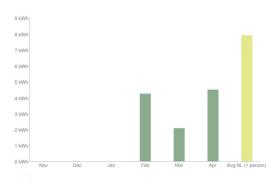


Programmes:



Total energy consumption (kWh):

The column to the far right indicates the average energy consumption for a washing machine in a Dutch household of 1 person.



Total water consumption (kWh):

The column to the far right indicates the average water consumption for a washing machine in a Dutch household of 1 person.

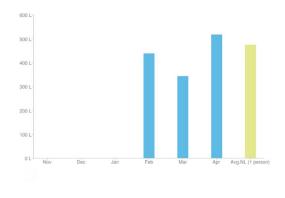


Figure 15: HOMIE new version monthly intervention email

Positively analyzing, the intervention email reports the consumption information and the user's behavior patterns which barely shown on the washing machine interface, the social comparison is also a good way to spur the user to a better behavior. However, most information that current intervention supplies are only informing the user of their behavior, consequently, the user knows their behavior, but still, lack the knowledge of improvement. Thus in the future concept, it can cover more intervention strategies to guide and stimulate the user.

Analysis with the IoT capabilities and sustainable behavior strategies framework(Bocken, Ingemarsdotter, Gonzalez), the HOMIE washing machine now implements in the guiding and steering intervention strategies, but only the monitoring level of IoT capability(Table 2). Similarly, the intervention relies on telling users about their behavior but not on leading them to a better behavior, therefore, it's necessary to put more smartness on guiding the user behavior.

HOMIE	Guding (Eco-info, Eco-choice, Eco-feedback)	Steering (Eco-spur, Eco-steer)	Embedded (Eco-technology, Clever design)
Monitoring	Eco-info: emails show consumption and social comparison	Eco-spur: Price incentive in business model	
Control			
Optimization			
Autonomy			

Table 2: HOMIE washing machine analysis

灰 Key Insights





User Research

This chapter is about the user research, the main research method is the user interview. It aims at finding out user's washing behavior patterns, understanding deeper on behavior motivations and users' opinion on sustainability. Therefore, it can be used to see how can the future design change user's behavior to be more sustainable.

- 4.1 Research Questions
- 4.2 Method
- 4.3 Results

4.1 Research Questions

According to Fogg's behavior model (Fogg, 2003), it is essential to learn about user's motivations, abilities, and triggers that can influence users with the goal of changing behavior. Therefore, the user interview is conducted to understand motivations of user's behaviors, how do they behave and what can influence them to behave in a more sustainable way in the washing phase. Following research questions will be answered by the interview:

- What are users washing behavior patterns?
- What are their concerns and pain points during the laundry process?
- How do users understand sustainable washing?
- What can trigger them to behave more sustainably?



The interview questions can be found in Appendix 3

4.2 Method

The user interview is a user-centered research method which has been widely used, long-standing and worldwide. Compared to other common research methods like the questionnaire and observation, through user interview the research can extend the topic for users to elaborate more on the topic. It is an insightful method for gaining the real thinking of users.

Six participants vary in target user groups, ages and genders including three HOMIE current users and three who fit the HOMIE user profiles were interviewed (Table 3).

Each target user group was chosen two users to ensure the integrity of the research. Three interviewees were interviewed on the phone while the other three was in a face-to-face interview, showing how they interact with the washing machine in a real context (Figure 16).

Participant	User Group	Age	Occupation
P1	Low-income(HOMIE)	33	Administration employee
P2	Low-income(HOMIE)	60	School secretary
Р3	Green Millennial(HOMIE)	29	Financial company employee
P4	Green Millennial	25	Chemistry Msc student
P5	Roamer	24	UX designer
P 6	Roamer	24	Design Msc student

Table 3: Information of participants





Figure 16: User interacts with washing machine while in the interview

4.3 Results

A qualitative analysis was conducted after the data was collected. Different color represents different users and their insights were put in different stages of their use process. The result is presented briefly by a user journey map which shows the user's interaction process, user's concerns and motivations, and potential opportunities. Other insights are used to answer the research questions.

The interview scripts can be found in Appendix 4

What are users washing behavior patterns?

Based on the information from interviews, users current interactions can be divided into six stages: sorting the clothes, filling the washing machine, putting detergent, choosing programs, start washing and receiving feedback email. These actions happen in a sequence within a single time period, while the feedback receiving stage happens at the end of each month, users receive the feedback emails of their behavior long time after their washing interactions.

In each stage, users have different goals, behave differently and care about different issues.

A customer journey map below is made to present the whole process: (Figure 17) In the customer journey map, key actions that multiple users do in common and interesting actions are highlighted by green and blue dots. Although in some situation users behave in the same pattern, they are motivated differently. Therefore, different motivations that lead to the same behavior are marked by yellow dots in the thinking part, which reflect users' opinion.

In the clothes sorting stage, users sort the dirty clothes into light/dark color or distinguish them by materials, like clothes and towels/sheets, then they fill in the washing machine with those clothes. This is to protect clothes from being dyed with each other, and to wash them in a proper way.

In the filling stage, some users would try to find other stuff to wash together if the clothes only reach a low load of the machine, but it's optional. Multiple reasons lead to that result. Some users think about making the cost worthy since they pay per wash. Some users say they

just want to make the consumptions worthy and feel less regret because they assume that washing one time no matter how many clothes in, the machine costs the same resource. Additionally, some users say they do that only because they are lazy and want to wash more clothes in one time. However, they would not put too many new stuff in to ensure the quality of the washing.

Then users will put detergent in the washing machine, by throwing a pod in the roller or users pour the liquid detergent. Considering the cleanliness and the harm to the clothes, users usually put the detergent based on former experience, or the indication on the detergent package.

Then users begin the washing setting, usually consisting of three steps: choosing the program, the temperature and the spin speed. Most users select the program based on clothes material, or they always use the same program. Users have tried no more than 3 programs. The reason for those behaviors is that they know little about different programs, for the sake of washing effect, it is easy and safe to use the program which has been tried before.

Generally, low temperatures (30,40) are for clothes while towels and sheets are washed in high temperatures (60,90) for the reason of hygiene. It is worth noting that some users would like to use the same program all the time with few changes in temperature and spin since that is easy and fast for them to operate. Research shows that washing temperature is the biggest influence on energy consumption, its reduction can save a remarkable amount of energy (Pakula & Stamminger, 2010). However users have no clue about it, the temperature decision mainly comes from the washing effect and clothes condition. In some situation, users use 30 degrees instead of 40 degrees for the sake of money they pay.

Eco mode is seldom used by users in the program setting phase because users have no need for that function since they seldom consider the environmental impact of their washing and other programs work well for washing clothes. They doubt about the washing effect of Eco function and don't want to take the danger to try it.

Then users will start washing immediately if they have no other requests, otherwise, they will use delay function to set the washing time for example due to thinking of the energy price.

	Sorting	Filling	Putting Detergent	
Steps				<u> </u>
User Goal	Distinguish clothes to ensure they won't dye each other.	Fill the washing load in a proper load.	Put the detergent in a proper amount which can ensure clean the clothes and make them smell good.	Choose the bes
Thinking	- The lighter clothes won't be dyed if they don't wash together with dark ones - Distinguish clothes and towels because they have different washing requests.	- What is the max load? - I want to wash as much as possible because I pay for every time - Am I putting the right amount of clothes? - How many clothes max but still can ensure the cleanliness? - I want to make the consumption worthy in this washing - I want to finish washing as much as possible since it takes some efforts for washing	- How much detergent should I put in? - How can I know am I putting the right amount? - Put similar amount detergent as last since the washing effect was good.	- Cleanliness is - Which progra without doing - Since the low choose it How can I cho short time? - How much en - How much is - I am always us me - Low temperat condition - High tempera - How does Ecc effect?
Doing	- Sort clothes and towels /sheets - Sort clothes in light/dark colors	- Try to fill the machine by searching other stuff to wash if it's not full load - Use a shopping bag to fill so that the amount is usually okay - Medium fill because not so much clothes to wash - Fill a few clothes to make sure of cleanliness.	 Put the detergent according to the instructions on the bottle/ use detergent pod Follow the instinct to put detergent Put it based on past experience if last time it makes clothes clean and smell good, it should work 	- Choose the proceed of the procedure of the proceed of the proceed of the proceed of the proceed of the procedure of the procedur
Frus- trations		- Not sure of the correct amount of clothes - Care about the cleanli- ness of the clothes.	- Don't know the exact amount of detergent - Sometimes mix detergent and softner	- No informatio - Don't know he condition - Don't know w they need to gi
Oppor- tunities	- Loading tool to put different clothes	- Try to decrease the washing frequence if not so much clothes - Load indication on the washing machine interface	- Detergent indication on the washing machine interface	- Best setting re - Transfer the co about(money, I - Sustainable d - Goal, prize an - Social compai - Eco & general

Figure 17: User journey map for washing process

Choosing Program	Start Washing	Feedback
	+	
st programs, temperature and spin for the g in a fast and easy way.	Clothes are succeefully washed.	Get information about their behabior and know how to improve.
always the first m & temperature can best clean my clothes harm to them? er temperature is cheaper I would like to lose a proper program & temperture in a ergy & water will each program cost? this wash? sing the same settings since it's easiest for ture and low spin can protect my clothes ture can ensure the hygiene mode work? Will using it affect the washing	- How is going with the washing status? - Sometimes feel the sound of washing machine is terrible - When to start the machine? Right now? - Is it cheap to start washing now?	- How is my performance? - How can I improve my behavior? - I feel pride if I did well in last month
rogram, temperature and spin based on als and colors 190) temperatures for towels and sheets 1 perature to protect delicate clothes 1 e the same settings 2 e default setting 2 using Eco mode	- Check the washing progress time by time - Choose the cheaper energy time to start washing	- Check own washing behavior report - Compare the performance with other - Sometimes will change behavior after reading the report
n related to consumptions ow to ensure the cleanliness and the clothes hich setting is the best for the clothes, now uess or judge by the experience.		
ecommendation onsumptions into things user care metaphor) efalut settings d encouragement rison comparsion	- Real-time monitoring - Proactive problem inspection - Cheaper energy time prediction	







What are their concerns and pain points during the laundry process?

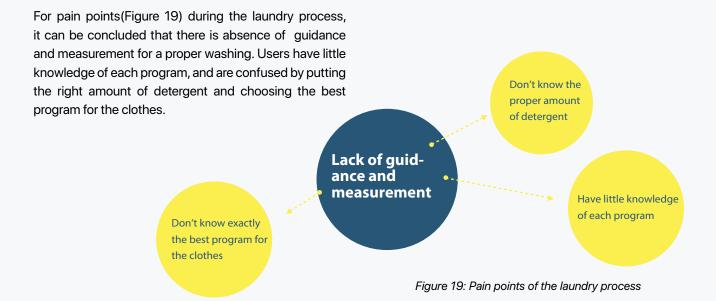
A categorization of motivations for common interactions and interesting interactions is shown to find the main concerns of users (Figure 18).

It is obvious that the washing effect is always the top concern, all users care about the cleanliness and condition of clothes, which means no compromise of it no matter what they choose to select. This is also the core goal of users doing laundry, all steps serve for that goal.

Apart from that, users are concerned about the money they spend since it is pay per use. But this factor is of a limited impact because the price is not so expensive. Users also care about the effort they take on operating the washing machine, they tend to choose the familiar settings because it's the most effortless and least time-consuming choice, they do not need to think anymore.



Figure 18: Categorization of top concerns



How do users understand sustainable washing?

From the interview, 4 primary insights can be defined on the understanding of the sustainable washing:

- Users are not clear about what the sustainable washing is. They are vague about the concept and different users have a different comprehension on the concept.
- Users have no clue on their own impact. This
 type of information is missing during the whole
 washing process. Although the HOMIE user can
 get the intervention email later, but it is too late to
 influence their behavior.
- Most users are not really concerned about the sustainable washing although sometime they behave in a sustainable way. They tend to be motivated by the results of showing the sustainable behavior, like economize some costs, reduce the sense of regret, be praised by others, gain selfsatisfaction. Sustainable usage in the current situation is an indirect benefit of user behavior. They do not think much about it during the laundry process.
- Some users are aware of sustainable washing, however they don't know what is right to do.
 They usually behave based on their own feelings.
 The specific guidance is missing.

How do they think of HOMIE current intervention emails?

They appreciate that at the end of every month they can receive the email telling them about their washing data, however, they feel there is a gap in influencing their behavior since next time when they start a new wash, they cannot remember exact data from last month for the sake of lacking consistency, the timing of current intervention is not right. A real-time feedback could work better in that case. Additionally, some users feel it lacks suggestions by only tell their behavior, but not saying how to achieve the improvement.

How to motivate them to change their behavior?

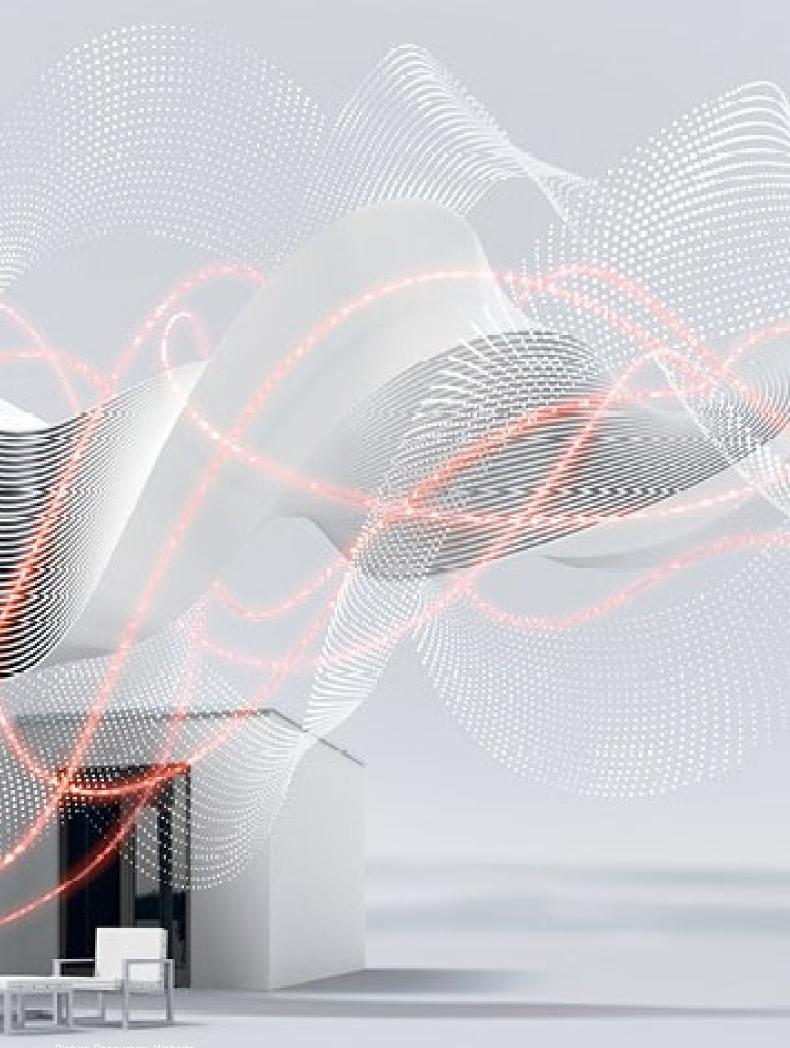
From the user interview insights, the washing impact in most situation is absent to the user, yet some factors, like the washing cost, social influence, and environmental impact concluded from the interview are meaningful and can motivate the user. Combining the two aspects by telling the user of their washing impact in the way that is meaningful to them can have a chance to encourage the user to change the behavior.



🖟 Key Insights

- Through the interaction cycle with the washing machine, four decision-making points in the filling, detergent putting, program choosing and start washing can be defined. The sustainable washing factors: the utility of loading, the detergent, and the water and energy consumption are impacted.
- Cleanliness and clothes condition are the top motivation of users to do the laundry, other factors like the money they spend and effort they take can influence on user's decision during the laundry process.
- The pain points during the laundry process are the uncertainty of the amount of detergent, little knowledge of diverse programs and uncertainty of selecting the most appropriate program.
- Users are not clear about what the sustainable

- washing is
- Users have no clue on their own impact
- Users not really care about the sustainable washing even sometimes they behave in a sustainable way.
 Actually, they tend to be motivated by the result of sustainable behavior, like economize some costs, reduce the sense of regret, be praised by others, or gain self-satisfaction.
- Timing is vital in triggering the user, however the current intervention emails tell users about their behavior but works little on affecting them because it's late on time and lack suggestion on improvement
- Creating the meaningful motivations of users, both rational and emotional can stimulate users to change their behavior.



Picture Resources: Website

05

IoT Products Benchmark

This chapter aims at researching how do current IoT products including smart washing machine and other categories of products design interventions to stimulate sustainable user behavior. The goal of the benchmark is to learn from the successful IoT products which can foster sustainable habits of users and to see the potentials on improving HOMIE washing machine user interface(UI) with new interventions

- 5.1 Smart Washing Machine Sustainable Strategies
 Benchmark
- 5.2 Sustainable Washing Machine Interface
- **5.3 IoT Products Inspirations**

To reach the goal, the benchmark should answer the following research questions:

- What sustainable intervention strategies do products use?
- How do those products design their interfaces to foster sustainable user behaviour?
- What are the possibilities and challenges for HOMIE to implement such interventions?

Therefore, the benchmark focuses on three aspects: understanding how do washing machines use sustainable intervention strategies, how are the washing machine interfaces designed to enable sustainable behavior change, and in addition, getting inspirations from other loT products.

In this case, IoT products that for benchmarking are chosen based on the following criteria:

- Washing machines and other IoT products that can stimulate sustainable usage, like saving energy and decreasing water consumption
- Smart washing machine UI is the primary choice while other smart products and mobile application UI which can change user behavior and foster sustainable habits are taken into consideration
- Interventions that are giving real-time feedback
- Interventions that employ most levels of IoT capabilities

5.1 Smart Washing Machine Sustainable Strategies Benchmark

Many big brands like Samsung, Whirlpool, Bosch and Miele put effort into developing smarter and more sustainable products. As technology develops, the washing machines use less energy, water and detergent. Together with the touch screen on the washing machine or the mobile application, smart washing machines can be controlled remotely. Among all washing machines, the Samsung WW8800M and Whirlpool WFL98HEBU are studied in this case.

Washing Machine Introduction

Samsung WW8800M is a conceptual washing machine which will be launched during 2018. The QuickDrive™ of it enables a series of smart and convenient features. Additionally, it boasts an Al-powered laundry assistant called Q-rator, which provides three key smart features that help manage laundry more conveniently through the app (Figure 20).





Figure 20: Samsung WW8800M washing machine and app

Featured functions of Samsung WW8800M are Laundry Planner, Laundry Recipe and HomeCare Wizard. With the app, users can control their schedule of washing, remote monitor the washing, be alerted of potential problems and quick troubleshooting. By filling in the washing information such as colors, material type of clothes and the dirty degree of clothes, the Al-powered function can give tailored recommendations of the wash programs for users.

Whirlpool WFL98HEBU enables smart assistant, smart stats, smart energy, smart nudges and smart alerts features. Users are able to have the product information, activate specific options when they are not at home with the application. The washing status is always being monitored and known by users. If any problem occurred,

the smart alert functions will let users know the situation as soon as possible. Apart from the user experience, the washing machine can track the energy usage, run in an off-peak time and help protect the planet by connecting to the "Smart Grid" used by utility companies (Figure 21).







Figure 21: Whirlpool WFL98HEBU washing machine, interface and app

Using the IoT capabilities and sustainable behavior strategies framework (Bocken, Ingemarsdotter,

Gonzalez), the sustainable intervention strategies of two washing machines are analyzed (Table 4 & 5).

	Guding (Eco-info, Eco-choice, Eco-feedback)	Steering (Eco-spur, Eco-steer)	Embedded (Eco-technology, Clever design)
Monitoring	Eco-feedback: Smart wash app for feedback of the washing status. Notifications.		
Control	Remote control	Eco-steer: Al recommendations for optimal cycle based user input	
Optimization	Proactively alerting users about potential problems and providing quick troubleshooting support.		
Autonomy			

Table 4: Samsung washing machine analysis

From the analysis table, it can be found that the Samsung washing machine mainly employs Eco-feedback and Eco-steer as the sustainable intervention strategy. Especially the AI recommendation function, it is used to recommend users a better program choice based on their washing input. The algorithms in the server can fast react to user's requests and give back the optimal choice for users. This function is good for steering the user's behavior and leads them to the sustainable choice. As for the IoT capability aspect, the washing machine is able to proactively alert the user with potential problems, which

is beneficial for the sustainability since that can prolong the longevity of the machine.

However, the AI function still needs the user's input, it may be more complicated in the process compared to the common machines. In addition, the machine is lacking on the energy and water consumption information, and the machine does not cater to the automation and Embedded intervention strategy, which proves it still not smart enough and has more eco functions waiting to be established.

	Guding (Eco-info, Eco-choice, Eco-feedback)	Steering (Eco-spur, Eco-steer)	Embedded (Eco-technology, Clever design)
Monitoring	Eco-feedback: Smart grid inter- face shows washing status Eco-choice: Give improvement suggestions.	Eco-steer: Energy advisor to tell when to optimize the schedule	
Control	Remote control	Eco-steer: Linear menu to pre-set functions, recommended cycle according to user's input.	
Optimization	The machine can diagnoses itself to predict the repairs		
Autonomy			Autonomously connected with Nest to find an optimal time for washing in "eco-boost". Smart grid runs the washing when energy is cheaper.

Table 5: Whirlpool washing machine analysis

As for the Whirlpool washing machine, it uses all sustainable intervention strategies and all IoT capabilities. Similarly, it is able to recommend the program and diagnoses itself in advance. It is also better than Samsung one, as it includes the feedback of energy consumption, and with the "eco-boost" function, the Whirlpool washing machine can autonomously connect to Nest by one button clicked by the user. The Nest thermostat then works as a trigger to facilitate the sustainable actions, like washing in the energy cheaper time and use a lower

temperature and less water. Additionally, in the Eco-steer level, it gives tailored advice to adjust washing schedule regarding energy consumption. Those are effective functions for the sustainable usage.

Although the functions are good, there is a lack of the user's self-reflection of their behavior due to the high smartness of the machine. Sometimes the user behaves sustainably without any conscious. It's risky of forcing the user.

Comparison with HOMIE

A comparison between HOMIE and two chosen washing machines is made in order to find HOMIE washing machine's potential features. Table 6 shows HOMIE,

Samsung and Whirlpool washing machines' sustainable intervention strategies.

	Guding (Eco-info, Eco-choice, Eco-feedback)	Steering (Eco-spur, Eco-steer)	Embedded (Eco-technology, Clever design)
Monitoring	HOMIE Samsung, Whirlpool	HOMIE Whirlpool	
Control	Samsung, Whirlpool	Samsung, Whirlpool	
Optimization	Samsung, Whirlpool		
Autonomy			Whirlpool

Table 6: Comparison sustainable intervention strategies of HOMIE, Whirlpool and Samsung washing machines

From the analysis of the last chapter, HOMIE's intervention strategies cover the Eco-information(emails show consumption and social comparison) and Ecospur (price incentive in the business model). Seeing in the IoT capability perspective, both of the strategies lay on the Monitoring level. In contrast with Samsung and Whirlpool, HOMIE has not implemented strategies on Eco-feedback, Steering levels, yet not in the control and optimization capabilities. Hence, it is important for HOMIE to employ more intervention strategies and IoT capabilities since those strategies work well in the other two machines.

In the sustainable functions aspect, the energy consumption in the feedback, tailored advice for adjusting washing schedule, program recommendations and the "eco-boost" function are effective functions that encourage the sustainable washing usage.

In addition to that, Samsung and Whirlpool are able to employ strategies and functions since they can show the information in an extra app or a big touchscreen on the washing machine. Thus, to load similar amount of information as they do, the UI of the HOMIE washing machine need to be redesigned to load more information.

🧖 Key Insights

- Both Samsung and Whirlpool machines have the intervention covering monitoring to optimization capabilities, and Eco-feedback and Eco-steel strategies.
- Whirlpool implements all levels of IoT capabilities and intervention strategies, including the Embedded and Automation level with the "eco-boost" function.
- The energy consumption in the feedback, tailored advice for adjusting washing schedule, program recommendations and the eco-boost function are effective functions that encourage the sustainable

- washing usage.
- The user's reflection should be considered in the intervention otherwise it is risky to lose the user due to over smartness of the machine.
- It is important for HOMIE to employ more intervention strategies and IoT capabilities since other brands have successful examples.
- The size of HOMIE washing machine interface need to be changed to give more space on sustainable information.

5.2 Sustainable Washing Machine Interface

In this project, the focus area is new possibilities for HOMIE washing machine interface. Therefore it is necessary to benchmark the user interface of other washing machines who has already stepped in this area. In this chapter, two machine interfaces are selected to study.

Figure 22 shows an interface of Whirlpool washing machine (website). Using this interface, users can choose the program, set the temperature and choose to delay start. Positively on the sustainable effect, the interface shows the users how energy and water efficient they've been with their cycle selection for each load over a month. At the end of each month, they can see how to improve the way they wash the clothes to save energy and water.

Although the sustainable information is shown on the interface, the suggestions for improvement are given monthly which is similar to HOMIE's current intervention, it's late on influencing the user. Tips update more frequently and are given for each washing should work better.

In figure 23, it shows an interface concept for the washing machine with the consideration of sustainable interventions. Users choose the program on the left menu and specifically set temperature, spin speed under each program. At the top of the interface, the Eco-rating and the cost of each program are instantly updated to provide the user a real-time feedback of the impact of their choice. On the right side, two buttons control the start washing are there. With the smart energy function working, the machine can predict when to wash can save money, therefore, a green button named as the "smart wash" with showing the information of saving cost is there to catch user's attention on a more sustainable behavior.

For the smart wash button, it's good to see how much money can save through the smart wash function. However, the amount of money is small and may have little impact on the user's decision. Display in another way for example the percentage, which the number is much bigger than the money may have a stronger impact on the user's decision.



Figure 22: Whirlpool washing machine interface(resource:website)





5.3 IoT Products Inspirations

Apart from washing machines, there are various other IoT products can give inspirations on design the new washing machine interface. Most products are chosen due to they are energy consumption related, which is an important sustainable factor in HOMIE washing machine.

HYDRAO Shower (Figure 24) is an IoT shower which is powered by the shower's natural water-flow, no external power supply is needed.

It lights up the water spray in different colors depending on the amount of water used to remind users how much water they have consumed during the shower. Therefore it allows users to instantly control the water consumption and the energy needed to heat it. In this case, the smart shower use colors in the product interface as the indication of sustainable behavior to remind the user, it's direct and intuitive for the user to grab the information. So that for HOMIE washing machine interface, the visuals can vary in more formats.

Figure 25 is the different screens of showing the energy usage. The combination of color and size of the circle together with the costs are designed to reflect on user's instant energy consumption. What's more, at the top of each screen there is a short comment text to feedback on energy usage situation. If the user consumes less energy, all the color are shown in green and the circle size is small, otherwise, the orange and bigger circle is for reminding and the red biggest circle is for a warning.



Key Insights

- The Eco-rating and cost of each program provide the user with a real-time feedback to influence their decision instantly
- The way of using the number to influence the user should be considered cautiously, usually, the percentage has a stronger influence since it looks
- much bigger than the washing saving shown in money.
- Visuals in the interface can vary more to raise the user's interest and make them easy to understand the contents.



06

Design Brief

Based on the gathered information from previous chapters, this chapter lists the personas, design goal, requirements and wishes for the new concepts. The future concepts have to meet with the list of requirements. The wishes are used to compare concepts with each other, in order to determine which one fits the criteria best.

- 6.1 Design Goal
- 6.2 Personas
- 6.3 Requirements and Wishes

6.1 Design Goal

This project focuses on decreasing the negative impact on the environment during user's washing interactions, therefore the design goal is:

Design the intervention based on the washing machine interface to raise user's awareness of sustainability, and stimulate a more sustainable washing behavior which reduces environmental impact in the washing interactions.

In the goal, "a more sustainable washing behavior" entails:

- Reducing the washing frequency: prevent the user from unnecessary washing
- Increasing the washing load: with the prerequisites of ensuring the washing effect, fill the washing machine as much as possible
- Decreasing the detergent usage: help the user to put a proper amount of detergent for every wash
- Choosing a lower temperature: stop the user from unnecessarily using high temperature.

- Selecting Eco mode: persuade the user to user Eco mode more
- Washing in an off-peak time: try to make the user start washing in the off-peak time to reduce the energy usage pressure.

6.2 Personas

Two personas resulted from the user research shown below are the target groups for the new intervention, they are mainly distinguished based on their sustainability awareness. Greene is a person who will consider sustainability in the life but lack of guidance, while Eva is the person who has no awareness of sustainable washing, considers more on washing effect and efficiency: (Figure 26, 27)

6.3 Requirements and Wishes

Design requirements and wishes result from all the previous analysis and user research. They are detailed explained in the sustainable intervention strategy and interaction categories in the table 7:

Cat	tegory	Requirements(should)	Wishes (can be)	
Strategy	Sustainable Interventions	Enable and balance different sustainable intervention strategies	Be implemented by HOMIE as soon as possible	
	interventions	Strategies are consistent with HOMIE business model	Enable collaboration with relevant companies	
	loT Capability	Engage more IoT capabilities of HOMIE washing machine, such as monitoring, optimization and automation.	Cautiously deal with the smartness considering the negative effect of forcing behavior changing	
Interaction		Assure the user of effective washing, keep the clothes in a good condition and cleanliness	-	
	Motivation	Create meaning to users to foster the sustainable washing behavior	Enable user's personalized service to match the diverse requests from the use	
		Meet users needs and desires during the whole laundry process	Keep on raising the user's interest and foster the long-term habit	
Ability		Provide easy, intuitive and effortless user interface	The design includes multi-sensory interactions	
		Leave the users a sense of control	·	
Trigger		Give the real-time information and make the trigger accessible to actions when motivations happen	Responsive in multiple platforms(washing machine, mobile, etc.)to fit with user's different situations	

Table 7: Design requirements and wishes



Greene

AGE 27

OCCUPATION Finanal Consultant

STATUS Single

LOCATION The Hague

INCOME Middle

EDUCATION Bachelor of finance

Bio

Greene is a financial consultant working in a medium-sized company in the Hague. For the job reason, he needs to travel a lot. In his spare time, he would like to do some sustainable volunteer and tries new tech product. He orders a HOMIE washing machine since "pay-per-use" is convenient for him to use

Motivations



Goals

- * Finish the clothes washing in a simple way
- * Find a convenient service for himself
- * Make a contribution to sustainable future
- * Be recognized in his community

Frustrations

- * Has limited spare time
- * Doesn't know how to measure his sustainable behavior accurately
- * Doesn't know how to improve the performance

Figure 26: Persona 1 Greene



"The balance between family and work is always my pursuit."

Eva

AGE 34

OCCUPATION HR

STATUS Married with a kid

LOCATION Rotterdam

INCOME Middle

EDUCATION Bachelor of Management

Bio

Eva is an HR in a commercial company in Amsterdam. Every day she travels to the company and picks up her kid from kindergarten. She is busy transferring from life to work. She is a family "manager" as well, therefore, she seeks for a better way to manage family, from the meals to investments.



Goals

- * Finish the housework easily and less time-consuming
- * Ensure the quality of different services
- * Decrease unnecessary family costs

Frustrations

- * Knows little about the washing programs, hard to make the decision sometimes
- * Doesn't know how to save the costs
- * Thinks that improving behavior can be troublesome



Concept Ideation

Considering the research outcomes from previous chapters and answering the research question "What IoT supported user interventions can HOMIE make to stimulate sustainable usage", this chapter will discuss the ideation process, the final concept direction and concept test 1.0.

7.1 Creative Session

7.2 Concept Iteration: From Initial Ideas to One

Concept Direction

7.3 Final Concept Direction: HOMIE Lifestyle

7.4 User Test 1.0

7.5 Test Analysis 1.0

7.1 Creative Session

To generate ideas that respond to the design brief, a creative session is held with 6 Msc design students.

The session starts with a short introduction to the project, following that every participant shares their own laundry experience and sustainable habits to encourage the empathy. Then they are divided into two groups to brainstorm and discuss four "How to" questions which related to sustainable behavior change and sustainable habits fostering.

The questions are:

- How to raise the sustainable awareness of users during the laundry?
- How to change users' behavior to more sustainable in the washing process?
- · How to keep user behaving sustainably?
- How do you think of future laundry?

A data analysis of the creative session is held to conclude the answers for the questions. During the analysis process, insights from participants which meet the design requirements and wishes are shown as follows:

• To raise the user's sustainable awareness:

The results for raising the awareness lean towards the showing of information and giving feedback level, to let the user know about the resources consumption, the indication of right choices and the reminding of unsustainable behaviors.

To change user's behavior to be more sustainable:

For this questions, solutions indicated are centered around interventions relating to the user's decision-making process. Giving guidance on a sustainable behavior, comparing the impacts of different choices for the user, or rewarding the user of a sustainable choice in both practical aspect like money or coupon, and the virtual aspect like the network identity.

To keep user behaving sustainably:

This question relates more to a long-term engagement. Solutions came from the session focus on using the build-up effect to link every time washing to accumulate a tangible benefit, for which the user can be motivated to behave sustainably for achieving their goals. For example, using the natural elements like desert or forest as the metaphor to reflect user's every time impact, if they keep on behaving sustainably, they can grow their own forest and get the sense of achievement. However, the point is what metaphor is attractive to the user, which is also the question to answer on the next stage.

Another method is to use the power of community, put the user into a dynamic competitive environment, users could also be encouraged due to the pursuit of a better performance.

About future laundry:

Results here show that users are always seeking the simplest and most natural interactions to finish the laundry, for example just throw everything into the machine, and then with little time, it is done automatically. Additionally, people are willing to use the smart products since they would pay fewer efforts.

7.2 Concept Iteration: From Initial Ideas to One Concept Direction

With the insights from the former research and the creative session, the ideation starts with the synthesis of different categories of insights. The ideation process is a dynamic iteration process in which different concept directions are refined and combined after the fast prototyping and tests, finally one concept direction is defined. The ideation process is shown in Figure 28.

The detailed contents can be found in Appendix 5

The ideation phase begins with four preliminary concept directions concluded from the session: Smart Assistant, Feedback & Guide, Community Power, and Personalized Interest. The Smart assistant concept explores the smartness of the washing machine to stimulate sustainable behavior, it uses real-time feedback and algorithm for washing recommendations. The second concept focuses more on the feedback and guidance of the laundry process, to raise the sustainable awareness of users while leaving the choice to commit to these actions on them. The third concept extends the power of community in the laundry process, using comparison to encourage sustainable washing and long-term user engagement. The fourth concept is a design which let the user choose their interest area and using that interest to create built-up effect (Lockton et al, 2010) to measure and steer user's behavior, thus achieving the goal of fostering a sustainable habit.

Although they are different in the contents and approaches, one feature they have in common is that they are all built around the touchscreen which could present more information during the laundry process.

With the pro's and con's evaluation results of each concept and new insights from the preliminary concepts, two refined concept directions: Smart Butler and Personalized Meaning were developed. The Smart Butler is a more intelligent concept based on the Smart Assistant. It gives the user the most appropriate and sustainable recommendation by detecting the fabric with i-DOS sensor(Bosch-home.com.au, 2018). After which, the machine makes most decisions and users only need to load the clothes in. Then a more sustainable wash takes place without changing their behavior.

In contrast to the cleverness of Smart Butler, the Personalized Meaning is a concept which a more user-centered concept in which washing information is shown in the way that is meaningful to users. Thereafter, users decide on how to act based on that information. The user could choose the meaningful display for them during the washing settings.

Evaluated by targeted users in both UX and sustainable behavior change aspects, the two concepts finally combined the smartness and user experience of Smart Butler concept, the personalization, the self-reflection and the micro-interaction of Personalized Meaning concept into a concept for further developing and testing which will be detailed discussed in Chapter 7.3.

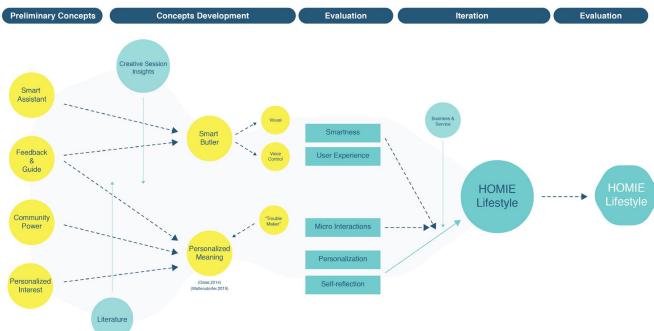


Figure 28: Concept development process

7.3 Final Concept Direction: HOMIE Lifestyle

Integrating the evaluation results from the former concepts, a new concept: HOMIE Lifestyle is created.

Concept Introduction

The HOMIE Lifestyle (Figure 29) is an intervention design that stimulates user's sustainable laundry process and long-term engagement. It is made up by four main parts: the load bag, the washing machine interface (Figure 30), the HOMIE application and personalized service.

Everytime the user starts to do the laundry, they can use the bag to see how much they could load with the different materials and try to full load by adding clothes to wash over time. With the iDOS sensors(Bosch-home. com.au, 2018) of the IoT washing machine, they get a recommended setting with the flexibility of changing the setting. They learn the impact of their washing choice in the way they are interested in(tree growing, money saving and honor gaining). When the washing starts, they can check the washing status on both devices. After the washing, they can check their sustainable impact and habit updating. Subsequently, to create the long-term behavior improvement, they can see their improvements and achievements with the app, and order the personalized incentives (coupon, plant seeds, stickers, etc.)from HOMIE.

HOMIE Lifestyle

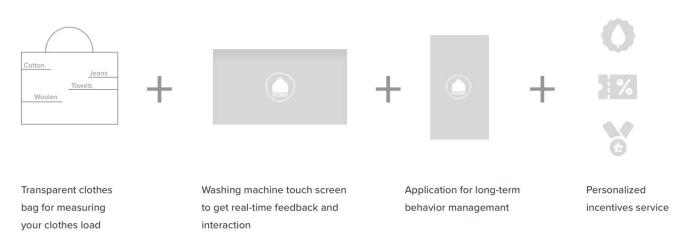
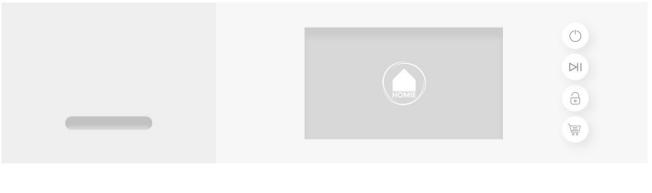


Figure 29: Concept: HOMIE Lifestyle



Detergent Box
Full load the detergent and every
wash the machine puts automatically

Touchscreen

Function buttons (Turn on/off, start/ pause, lock, fast detergent buying)

Figure 30: Concept: HOMIE washing machine interface

Features

Evaluated with personas, requirements and wishes, the concept has features as follow:

Covering diverse sustainable intervention strategies and enabling multiple IoT capabilities with the functions

HOMIE Lifestyle	Guding (Eco-info, Eco-choice, Eco-feedback)	Steering (Eco-spur, Eco-steer)	Embedded (Eco-technology, Clever design)
Monitoring	Eco-feedback: real time feedback on the sustainable impact of different choices Eco-information: learn user's habit based on the washing data	Eco-spur: The long-term eco wash rewarding Eco-spur: The over-washing monitoring and punishment	
Control	Eco-information:Personalized meaningful sustainable information display		
Optimization		Eco-steer: Recommended more Eco program according to the clothes detection	Eco-technology: Smart grid delay suggestion on the washing in the cheaper energy time.
Autonomy			Clever design: Put the proper amount of detergent based on the clothes

Table 8: Concept HOMIE Lifestyle IoT-sustainable behavior framework

Create different meanings for the different users, giving the personalized choices

The user chooses their interested topic as the game and will be responsible for their choice, and their sustainable impact will be displayed in the way they choose. They can

reach the achievements if they obey the rules and this also ensures their behavior improves. Otherwise they get "punishment" like having their tree see stunted growth.

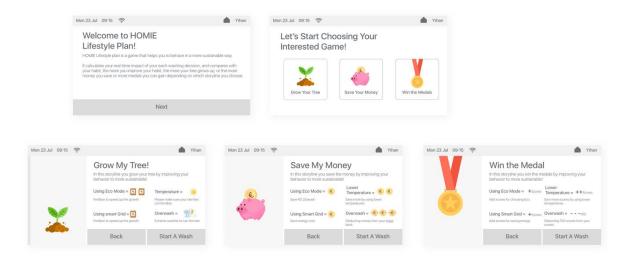


Figure 31: Concept HOMIE Lifestyle meanings

Improve user's pain points during the laundry

using the bag and automatic detergent dispensing as well as providing real-time feedback to change the "blind

washing" situation, guide and assist the user to finish an appropriate washing.



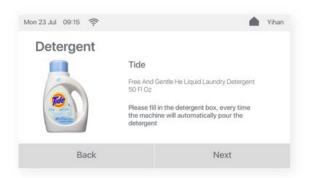


Figure 32: Concept HOMIE Lifestyle smart detergent putting

Micro interaction to enhance the attractiveness to users

Small subtle interactions in the washing machine interface can give the user a surprise and improve the interestingness of interactions. For example, the

animations of the tree's reaction for different temperature choices. Therefore they would not get tired of the interaction easily.

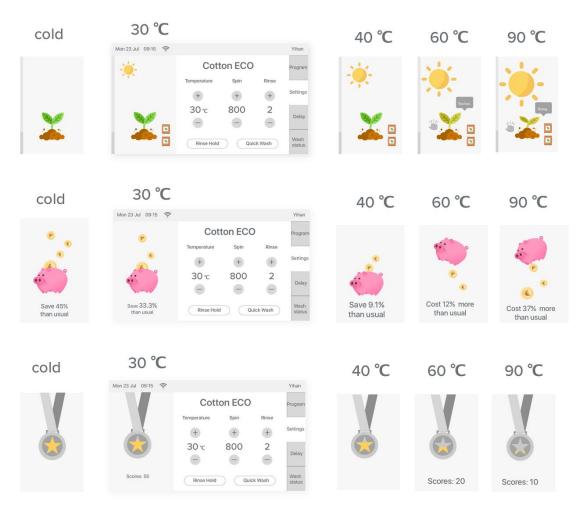


Figure 33: Concept micro-interactions

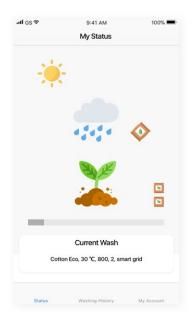
Long-term engagement for the user to foster sustainable habit

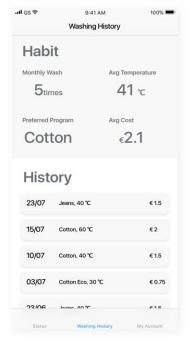
Users can see how their behavior change to grow a forest, save a lot of money and earns many medals in the app. The sense of accomplishment can encourage

user to insist on behaving in a good way to continue their achievement streak.

Personalized awards service

Users can go to the HOMIE service page in the app to check the awards. This can keep on attracting them to behave in a good manner over time.





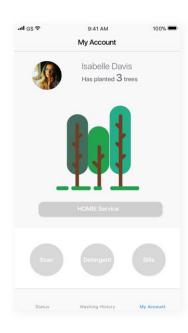


Figure 34: HOMIE mobile application

User Flow

Figure 35 shows the user flow of HOMIE Lifestyle concept, it mainly focuses on the washing machine interface.



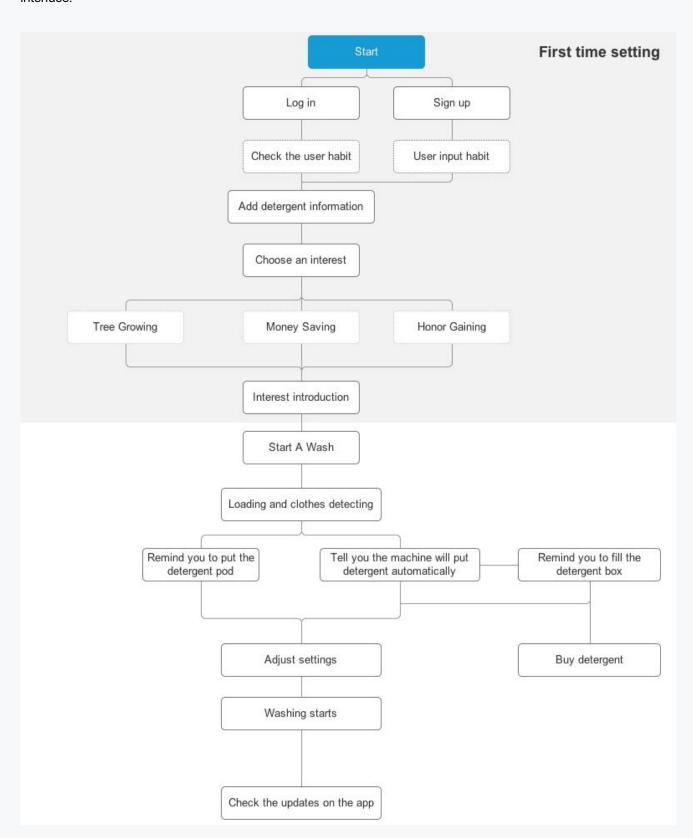


Figure 35: Concept user flow

7.4 User Test 1.0

In order to validate the concept "HOMIE Lifestyle" 's user experience and sustainable impact on user's washing behavior, a user test with 6 participants was carried out with a basic interactive prototype. The participants were first introduced on HOMIE washing machine and the payper-use business model, then a pre-test interview was conducted to get more information on user's washing behavior and sustainable washing knowledge. After the brief introduction of the concept "HOMIE Lifestyle", the participant was asked to finish the washing setting with the washing machine interface prototype. Following the tasks, a post-test interview was carried out to learn the participant's feelings and opinions on the concept in detail. Finally, the participant filled in the SUS evaluation form(John Brooke, 1986) and sustainable impact form to evaluate the concept quantitatively.

Research Questions

"What is the usability of the concept?"

"To what extent can the concept stimulates sustainable washing behavior?"

Participants

6 participants who fit the persona profiles, "Greene" and "Eva", spread in gender and age and are HOMIE's potential users participated in the test. Since one of the test goals is to improve the concept, the ideal participant should also have some creative thinking skills or be enthusiastic about trying new things.



The detailed plans can be found in Appendix 8













Figure 36: Concept HOMIE Lifestyle user test 1.0

7.5 Test Analysis 1.0

User Experience

SUS(System Usability Scale) (John Brooke, 1986) is used to evaluate the concept's user experience. It consists of a 10 item questionnaire with five response options for respondents (Table 9); from Strongly disagree to Strongly agree. A SUS score above 50 is considered as acceptable, above 68 would be considered above average.

10 Items of System Usability Scale

- 1. I think that I would like to use this system frequently.
- 2. I found the system unnecessarily complex.
- 3. I thought the system was easy to use.
- 4. I think that I would need the support of a technical person to be able to use this system.
- 5. I found the various functions in this system were well integrated.
- 6. I thought there was too much inconsistency in this system.
- 7. I would imagine that most people would learn to use this system very quickly.
- 8. I found the system very inconvenient to use.
- 9. I felt very confident using the system.
- 10. I needed to learn a lot of things before I could get going with this system.

Table 9: SUS items

In the table 10, the SUS score of each participant together with the score for each question of each participant is shown, the ideal score means the score in the best situation. score 3 means a neutral attitude to the question which are highlighted by the lighter pink, while other extreme opposite scores to the ideal score are highlighted in a darker pink. The question that are given more than 4 negative answers are highlighted as well for a further discussion.

From the SUS scores overview, the usability of the concept is acceptable since all the scores are above 50, but there is still a big space for improvement since only one score above 68. One reason is that the result is partly negatively influenced since the prototype is not a fully functional prototype, which makes the participant feel confused sometimes.

Combining the post-interview of each participant with

the detailed SUS scores, it indicates that question No.2, No.5, No.9 and No.10 result in a negative way, and lead to the low final SUS scores.

The most severe one is the question No.2, which according to participant's interview, the concept is complex since a lot of information is shown on the interface, and the laundry setting process is prolonged. That is especially so during the "choosing interest" step where some participants are tired of reading the texts and feel that it is complicated to make the choice. Additionally, some of them are worried about having to choose one direction as they are interested in both the money saving and tree growing information. As such the user flows and interface should be simplified.

However, because an intervention is usually an addition to the general process, it is not surprising that participants have more mental loads than expected. This could partially influence participants' judgement. Other than the concept itself, the test process can be another reason that leads to this result, since the test starts from the first setting process, which gives the participant a feeling that the laundry process is prolonged. This should be avoided in the future test.

As a result of the complexity of the system, the participants are therefore not confident about using the system, which shows a negative result in question No.9 and No.10. If the complexity is refined and the design is more intuitive, the participant can be more confident and can understand the process easily without learning too many things.

For question No.5, the participants mention that they feel like they are losing the link between the touch screen and the physical button on the interface. They tend to touch the screen for starting the washing instead of using the button. However, considering that the washing machine is a product, the physical button is necessary to exist in the case of the failure of the touchscreen. Thus, the integration of the interface needs to be improved by considering and reinforcing the button indication.

	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	SUS
P1	4	4	4	3	4	1	5	2	2	3	65
P2	4	4	4	2	3	1	4	3	3	4	60
P3	4	3	3	2	3	3	3	2	3	2	60
P4	3	4	4	4	3	3	3	2	3	2	52.5
P5	3	4	4	1	2	3	4	3	3	3	55
P6	5	3	3	1	4	2	4	2	4	3	72.5
Ideal score	5	1	5	1	5	1	5	1	5	1	100

Table 10: SUS scores for each question of each participant

Sustainable Impact Scale

Sustainable impact scale is made based on the design goal of stimulating sustainable user's behavior and fostering a sustainable habit. It consists of 6 items for participants to reflect on their attitude towards the concept(Table 11). 5 is full score for each question, and 30 is the full score for all the questions, which means strongly agree on that behavior change.

Sustainable Impact Scale

- 1. This concept raises my awareness of laundry sustainability
- 2. I will load more clothes when doing the laundry
- 3. I will use less water and energy
- 4. I will use Eco mode more often
- 5. I will use a lower temperature for washing
- 6. I will keep behaving sustainably with the concept

Table 11: Sustainable Impact Scale statements

In the table 12, the sustainable impact score of each participant and score of each question for each participant are shown, the sum score above 18 would be considered the concept is effective in stimulating sustainable washing behavior. The neutral scores are highlighted with light pink while the low scores are highlighted with dark pink.

The overall result shows that generally, the concept is able to stimulate sustainable washing behavior since all participants give the scores above 18, which means a neutral attitude to the concept. Additionally, during the observation of the test, 3 participants choose cold water to wash, 2 choose 30 degree and only one participant

chooses 40 degrees, which lower than the Dutch average. Furthermore, 4 of 6 participants choose to use the Eco mode which is better than the HOMIE data.

Looking into the detailed score of each question, it points out some problems as well. The question No.4: "I will use Eco mode more often" gains the lowest score. Although the sustainable information or the money saving information are given to the participant, the participant sometime does not want to use the Eco mode due to the time it spends. They are only willing to use it when they have extra time on hand.

For the question No.3, the participants feel this type of information is not clear in the concept. The question No.2 is evaluated negatively for the first participant since the concept wasn't well explained at the beginning. Later it goes better because the test procedure is adjusted. The question No.6 refers to long-term engagement, the participants mention that the money can always get their attention, however in the tree plating part, they can be encouraged at the beginning, but they are doubtful about the interests because they do not feel the tree belong to them, so that they may get tired of the animation, meaning that the stimulation will fade gradually.

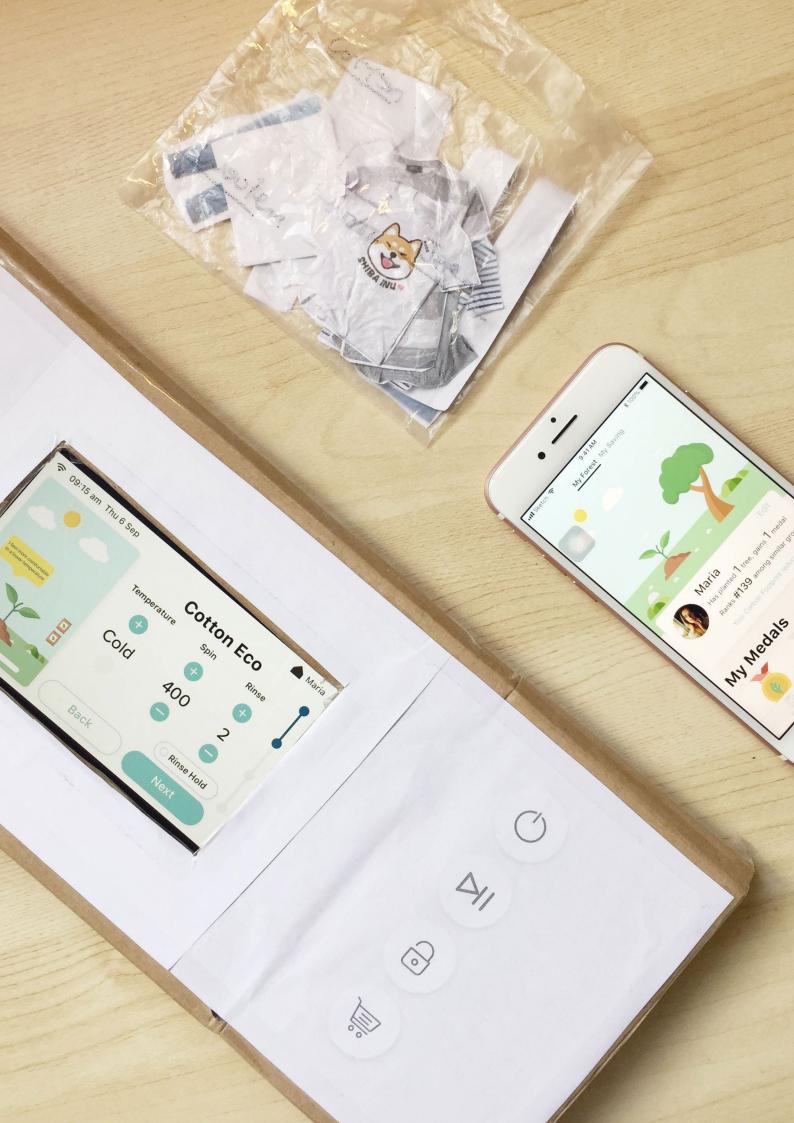
Apart from the evaluation form, the observation indicates that of 6 participants, 3 choose to plant the tree while other 3 choose to display the money. Those two make them reflect on their behavior while they cannot feel the similar meaning from the medal idea.

Participant	No.1	No.2	No.3	No.4	No.5	No.6	In total
P1	4	2	3	2	4	4	19
P2	4	4	4	3	4	4	23
P3	2	5	5	5	5	5	27
P4	5	4	4	4	4	4	25
P5	4	4	3	4	3	2	20
P6	5	4	5	5	4	4	27
Ideal score	5	5	5	5	5	5	30

Table 12: Sustainable impact scores of each question

Improvements

- The interface and the user flow should be simplified to be more intuitive for users to interact. (Add automatically steps, step guides, use more visuals, update the animation more often, etc.)
- Add social comparison to spur the user.
- Explanation on the Eco mode and combine quick wash to encourage the user to use more Eco mode
- Delete the medal one and combine the money saving and tree planting storylines.
- Reinforce the sense ownership of the tree planting process, bond the tree with the user more in the emotional aspect
- Add stage rewards to keep on encouraging the user and therefore enable the long-term engagement
- Improve the integration with the touchscreen and the physical button



08

Concept Development

In this chapter, the design concept HOMIE Lifestyle is improved based on the result and other findings of user test 1.0. Then user test 2.0 is conducted with both targeted users who fit the persona's profile, and HOMIE employees to evaluate the concept's effect on sustainable washing behavior stimulation and to iterate the concept for the final design.

- 8.1 Concept Detailing
- 8.2 User Test 2.0
- 8.3 Test Analysis 2.0

8.1 Concept Detailing

After the review, the washing machine interface and the application have been improved in both flows and displays, and concept version 2.0 is made.

Concept 2.0

UI Style: Buttons and bars, Color Palette and **Fonts**

User interface plays the vital role in creating the user interaction. It guides the user. The review of the first version design exposes some problems in the usability, therefore in this version, the color, the buttons and bars, the flows are all reconsidered.

The floating button originally comes from Google Material Design, it makes the button stand out, and easy to find, which can guide the user more clearly (Figure 37).

In addition, for the last version the user feedbacks that sometimes they feel lost in the process. Therefore a progress bar showing the setting process is added this time to better navigate the user (Figure 38).

The color palette composes the primary color, which is the "HOMIE green", and other colors are desaturated to work better with the primary color (Figure 39).

The fonts, San Francisco which is the newest iOS system font is chosen since it's clean and simple, shows the feeling of harmony with other components (Figure 40).

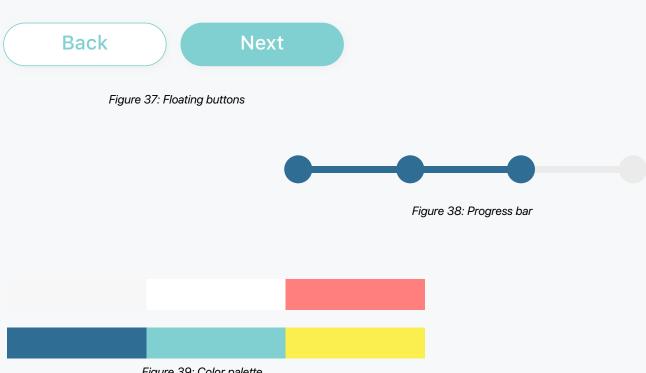


Figure 39: Color palette



Figure 40: Fonts

Add the energy and water consumption information, the social comparison with the Dutch average of the similar group as the user is, and the tailored washing suggestions before every washing.



Figure 41: "Your Habit" page

The medal game was removed. Instead of letting the user choose their interest, asking them directly on whether they would like to try the growing tree game. If they are willing, then it goes to the tree game, otherwise it will present the impact in the money way.

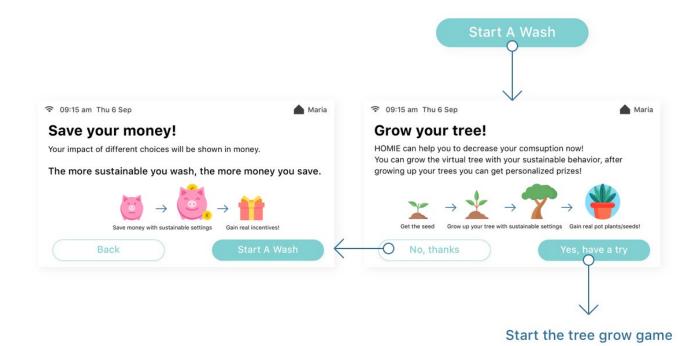


Figure 42: Current "Interest choosing" process

Add the function that "give a name to your tree", to improve the user's sense of ownership of the tree, and leave the possibility to grow different trees in the future concept.



Figure 43: Give a name to your tree

Hide the program information and leave the more vital information clean. In the old version the program information is displayed and leads to an information overload problem. In the new design, only the user tap and hold the title can they see the detailed introduction of the program.



Figure 44: Program details

Using the sun color and environment color change to represent the temperature setting instead of the sun size.



Figure 45: Sun color changes to different temperatures

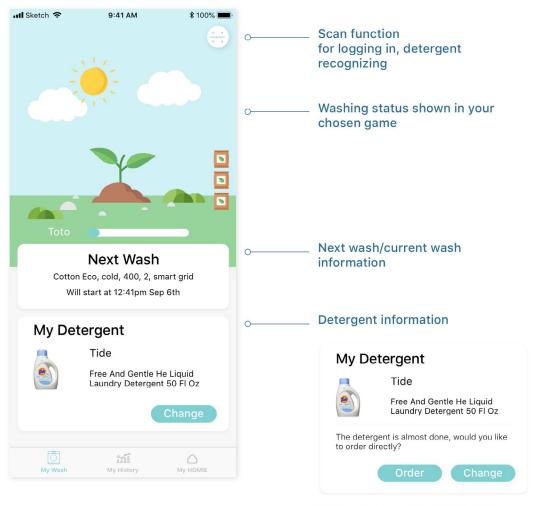
Light up the physical button when the user finish the washing settings, to indicate the user when to press.



Figure 46: Integration of digital and physical interface

Improvements of Mobile App

My status: check the washing status and washing information, and check the detergent information. When the machine predicts the detergent will use up, it will remind the user to order.



Detergent purchase prediction and order directly

Figure 47: Application-My status

My history: this part focuses on washing data. It reports the washing habit and compares the user's habit with Dutch average of the similar group and gives the user tailored washing advices. The user can also check the bills and washing history.

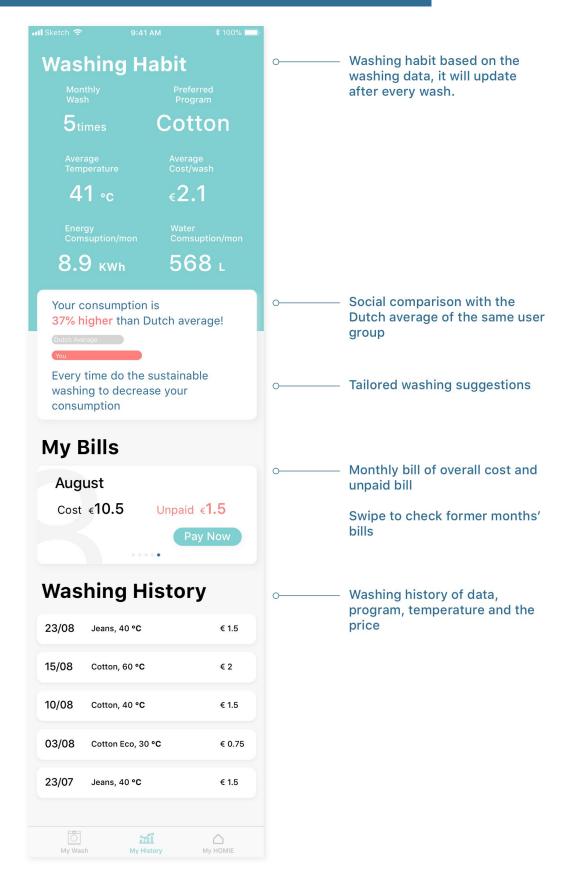


Figure 48: Application- My history

My HOMIE: This part is the long-term encouragement part. The user can check the game progress, personal ranking and medals. Then if his/her achievements reach to a level then the user can get the real awards from HOMIE. The real awards can partly come from collaborated company like Albert Heijn.

For the game, the app default displays the game the user chooses for the first time on the washing machine. The money is always calculating, the user who chooses the tree planting can also see how much money they save on the mobile application in the beginning. For the user who chooses the money saving, they can start to plant

the tree at the application as well, but the tree will grow from zero. Once the user has two games, they can switch the display card on the interface to check the impact in different ways. However, they can only select one type of awards.

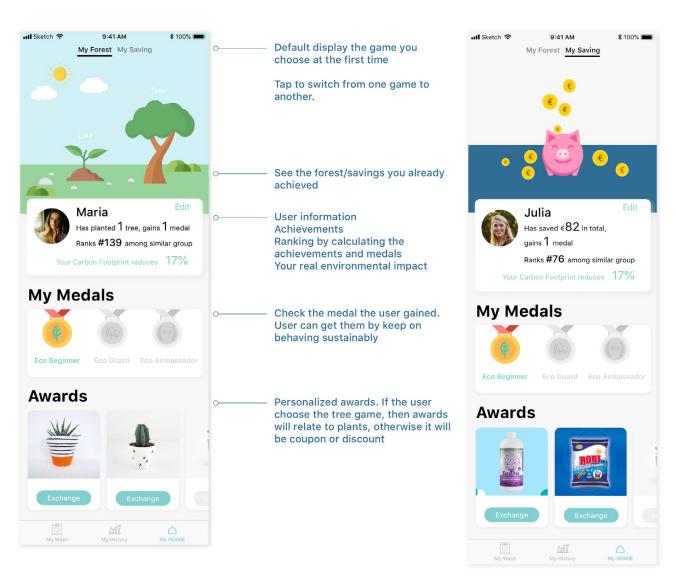


Figure 49: Application- My HOMIE

User Flow 2.0

Figure 50 shows the user flow of HOMIE Lifestyle concept 2.0, including the washing machine interface and the mobile application.

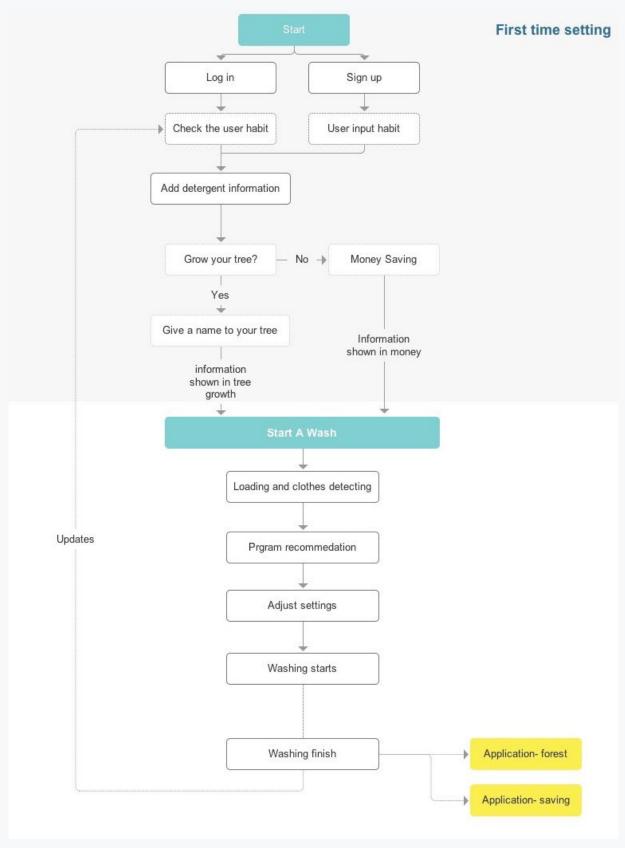


Figure 50: Concept user flow 2.0

8.2 User Test 2.0

Research Questions

"What is the ux of the concept?"

"To what extent can the concept stimulates sustainable washing behavior?" (short term and long term)

"How do different features impact on sustianable washing behavior?"

Participants

9 general participants who fit the persona profiles and 1 HOMIE employee, spread in gender and age participated in the test. The user group is defined by the pre-test questionnaire and pre-test interview. The detailed information is shown in table 13:

Figure 51 shows the test settings. The washing machine's interface prototype was put vertically to simulate the real situation while the HOMIE bag and mobile phone were put on the desk. The recorder and camera were put on the desk as well to record the interactions and user's opinions.

The user test is conducted by asking participants to finish two main tasks, three evaluation forms and two interviews. Figure 52 shows the user testing process.



Participant	User Group	Age
P1	"Eva"	31
P2	"Greene"	24
P 3	"Eva"	32
P4	"Greene"	27
P5	"Greene"	22
P 6	"Eva"	26
P7	"Greene"	25
P8	"Eva"	24
P 9	"Greene"	30
HOMIE Employee	"Eva"	30+

Table 13: User test 2.0 participant information

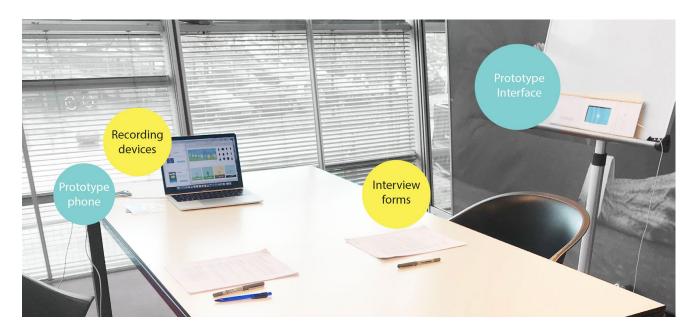


Figure 51: Test settings



Figure 52: User testing process

"It reduces the stress of first using, it's quite friendly."

- P1 "Eva"



- P4 "Greene"

8.3 Test Analysis 2.0

In this section, the results of the user test will be analyzed. The conclusions from the results will be used in Chapter 8.4 Improvement. The quantitative data collected during the user testing included: SUS, sustainable impact, and invention impact. 9 general participants gave both qualitative data and quantitative data, while the HOMIE employee's feedback was mainly in the qualitative aspect.

User Experience

Same as user test 1.0, the SUS scale is used to evaluate the UX of the concept. From the SUS scores overview, the usability of the concept is good since all scores are over 68, and an obvious improvement in shown compare to the last test(Figure 53). Most participants feel the concept is easy to use, the interface is clear and the process is intuitive to them.

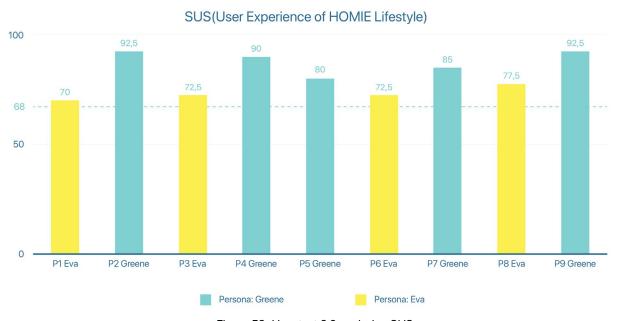


Figure 53: User test 2.0 analysis - SUS

However, analyzing two personas individually, it is obvious that the "Greene"s evaluate the concept better than "Eva"s. According to the test interview, the reason is that the intervention adds more steps compare to the normal washing machine they use so they need to pay attention to more information. Additionally, there is no indication on the money choice on the "Grow your tree" page, so that they feel a little uncertain about the result of choosing "No thanks".

Although all the participants are satisfied with the user experience of the concept, the way of visualization can still be improved. Some contents should be replaced by charts or pictures for the reason that users are not all sensitive to texts and numbers.

"568L seems a large amount of water, but I can't feel it. Maybe just tell me how many baths I can take with this amount of water."

The evaluation forms can be found in Appendix 10

- P2 "Greene"

Sustainable Impact Scale

Likewise to test 1, the sustainable impact scale is to evaluate whether the concept has achieved the design goal or not.

Figure 54 shows the average score of 6 questions for

each participant. 3 means a neutral attitude while 5 means fully agree. From the overview, it can be concluded that the intervention concept is effective in stimulating sustainable behavior since all scores are higher than 3.5, which is 70% of the full score, entails that participants agree on the effect.

Sustainable Impact Scale (Per participant)

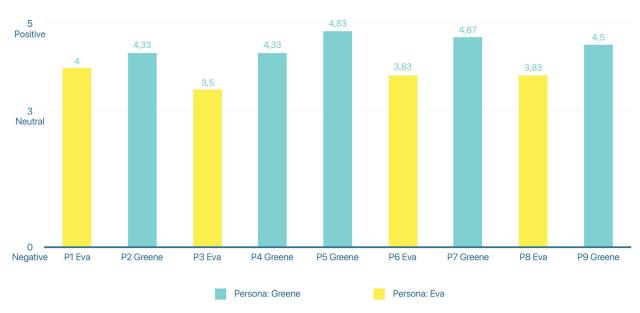


Figure 54: User test 2.0 analysis - Sustainable Impact Scale - per participant

Apart from the data coming from the evaluation form, data recorded during the test observation also proves the effectiveness of the intervention. Of 9 participants, all of them chose the Eco mode but 8 chose the quick wash as well due to a long time. 5 of them chose the cold water while the other 4 chose 30 degrees to wash the daily clothes(t-shirts, pants. etc), and 7 of them decided to delay the wash in an off-peak time with the recommendation from the machine. The choices are more eco than the Dutch average. However, the data here can have the deviation since the participants behaved when they were observed, which can partly influence on their performance.

Although the intervention has achieved the design goal, the differences between the two personas are apparent. Overall the "Greene"s gave higher scores than "Eva"s, "Eva"s will change their behavior somehow but not as much as "Greene"s. In conjunction with the qualitative data coming from user interview, the sustainable information can give hints on "Eva"s on the sustainable aspect, yet they still stick to their ultimate goal, to ensure

the washing effect. The intervention let them know the sustainable information, can persuade them from choosing 40 degrees to 30 degrees, but not always to cold water since the washing effect is still the top concern.

In comparison, the "Greene"s are more willing to change their behavior because concept brings them the chance and guides them, and they can feel the sense of achievement to see the tree growing. While for the "Eva"s, the benefits of sustainable behavior need to be reinforced during the interactions.

"The tree is like a partner of me, we grow better together."

- P5 "Greene"

"There is a gap to push me to behave sustainably, but this intervention can guide me to do."

- P1 "Eva"

"I think your concept is really brilliant, to show the user real-time impact of their choices rather than at the end of the month."

- P4 "Greene"

"Compare to other washing machines, this one is more fun, and you feel doing something good."

- P6 "Eva"



he way of showing sustainable information is good"

- HOMIE Employee



Figure 55: User test 2.0 analysis - Sustainable Impact Scale - per statement

Seeing in the statements' perspective, the average scores of 9 participants for each statement are all higher than neutral, all scores are higher than 3.5, 70% of full score, which reflects that the design goal is achieved by the intervention.

One statement scored lower than 4 is No.2, "I will load more clothes when doing the laundry". This mainly points to the problem with HOMIE bag. During the interview, the participants mentioned that the HOMIE bag can help them to measure the clothes volume, but if it's not full they are acceptable since they want to ensure the washing effect and, they cannot find other clothes to wash together every time. That means the bag tells the result a little bit late. Additionally, in the extreme case, some users are already overloading the clothes, while the bag reduces the volume of clothes. Therefore, the bag's design should be more proactive and can consider telling the user the clothes volume range.

Similarly, the "Eva"s gave lower scores than "Greene"s did. Especially in statement No.2(I will load more clothes when doing the laundry) and statement No.6(I will keep behaving sustainably with the concept). The difference in average scores of the two groups is the most apparent.

The reason for No.2 is mentioned before, but for No.6, which is related to the long-term engagement, the intervention has the effect on keeping the user there, but

the "Eva"s said that real awards intervention are the most appealing of all, yet it depends on what kind of awards they are. Otherwise, they would not set it as a goal to strive for. For those who chose the money, although they were saying that money could always encourage them, they would still consider practical problems when doing the washing, so they are not as optimistic and confident as "Greene"s.

Instead, for "Greene"s they are more like to be continually engaged because there are more elements to keep them since all of them chose the tree game, in which the features like forest growing, medal winning, ranking, can trigger them together.

"It is an accumulated effect, with time goes by I will feel the sense of achievement become stronger."

- P7 "Greene"

Another important part of the test is the question that "To what extent will you still interested in the concept in 3 years", especially for the ones who choose the tree. 3 initial ideas were shown to the participant for the long-term engaging to ask for their opinions. Figure 56 shows the 3 ideas:

7 participants who chose the tree game answered the question, all of them appreciated the idea that the tree lives in the same environment as they do, they felt the tree is more real in that situation. For the two ideas on planting the new tree, 5 of them selected to choose the tree species by themselves, as a consequence of designing their own forest.

"I will keep on planting the tree, I want to make my own forest!"

"It brings the real world to the digital world"

- P1 "Eva"

- P9 "Greene"



Choose the tree species every time you plant a new one



Unlock the tree with the difficulty increases

The tree's living environment is same as the owner, for example the same seasons and same holidays

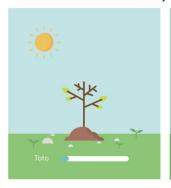








Figure 56: 3 ideas for the long-term attraction

Intervention Impact

The intervention impact is conducted to evaluate the effectiveness of different interventions in encouraging sustainable behavior. And since all the features are the practical test based on the literature, the scale is also used to verify the effect of employing various sustainable intervention strategies, behavior change dimensions, and IoT capabilities on sustainable washing behavior stimulation. The features are listed in table 14.

Statements of features on behavior changing

- 1. HOMIE bag to measure the load
- 2. Social comparison and tailored washing advice
- 3. Real-time sustainable feedback of choices
- 4. Personalized meaningful sustainable information display
- 5. The personalized game updates(plant trees successfully, save more money)
- 6. The real long-term sustainable wash incentives
- 7. The over washing punishment in the game
- 8. Program recommendation(more on Eco mode)
- 9. Smart grid recommendation
- 10. Automatically putting the detergent

Table 14: Features of concept

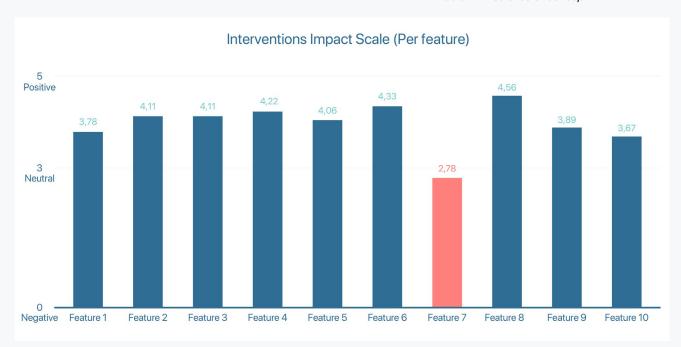


Figure 57: User test 2.0 analysis - Intervention Impact - per feature

Figure 57 shows the average scores of 9 participants for each feature. Score ranges from 1 to 5, 5 means the feature strongly influences on participants' behavior.

The figure indicates that almost all the features have the positive impact on user's behavior change, especially

feature 8(Program recommendation), feature 6(The real long-term sustainable wash awards) and feature 4(Personalized meaningful sustainable information display). During the test, these interventions were mentioned a lot as well to motivate users. Users felt they are being guided, and motivated to behave sustainably.

"Seeing I'm saving money can always encourage me to behave better."

- P8 "Eva"

"The machine recommends on Eco mode, okay I will trust it, it's the expert on washing"

- P9 "Greene"

Looking back to the literature, the features are generated based on the sustainable intervention strategies and IoT capabilities(Table 15). The effectiveness of the features on stimulating the sustainable behavior can verify that the sustainable intervention strategies, no matter the user-centered part or the product-centered part, together with IoT capabilities are effectual to foster sustainable behavior. Only one feature, which is the overwashing

reminding got the lowest score from all participants. It was unable to influence on user's behavior. This is because the timing of the intervention is not right, it is too late to inform the user, and it makes the user feel negative since it is kind of a negative feedback for user's behavior. So for the Eco-spur strategy, where the feature initially came from, it is not so effective on using such a negative punishing strategy.

HOMIE Lifestyle 2.0	Guding (Eco-info, Eco-choice, Eco-feedback)	Steering (Eco-spur, Eco-steer)	Embedded (Eco-technology, Clever design)
Monitoring	Eco-feedback: real time feedback on the sustainable impact of different choices Eco-information: learn user's habit based on the washing data, social comparison	Eco-spur: The long-term eco wash rewarding Eco-spur: The over-washing monitoring and punishment	
Control	Eco-information:Personalized meaningful sustainable information display		
Optimization		Eco-steer: Recommended more Eco program according to the clothes detection	Eco-technology: Smart grid delay suggestion on the washing in the cheaper energy time.
Autonomy			Clever design: Put the proper amount of detergent based on the clothes

Table 15: Concept HOMIE Lifestyle 2.0 IoT-sustainable behavior framework

Limitations

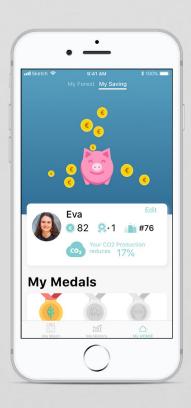
The result of the user test is positive overall but there are some limitations as well as follows:

- The small testing groups. 10 participants in total test, which support a qualitative research, but it's not enough for the quantitative research.
- Although differing in the behavior patterns, the main participants are the Millennials due to the limited access to multiple users of the author, so in the future, the test can be finished with more age ranges.
- For the intervention impact part, with the limitation of numbers of participants and the mix strategies used on one feature, the further verification with more participants and the clear comparison experiments are needed.

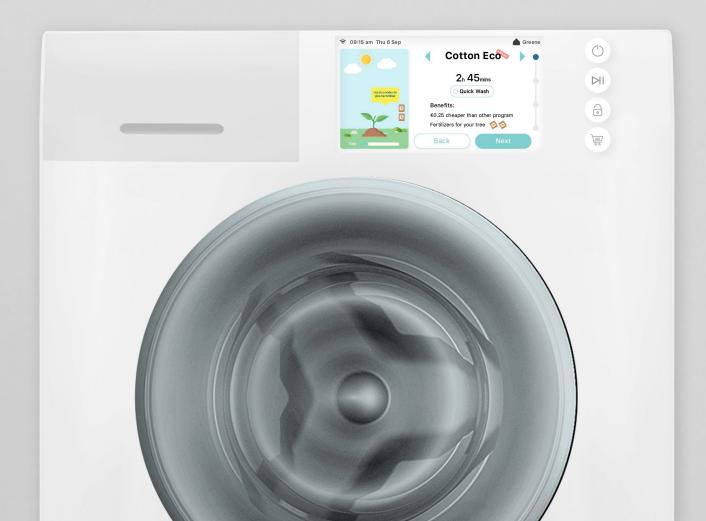
Improvements

Regarding the test results and other findings from the user test, some important improvements for final concept are listed:

- More visuals and charts in the habit part on both washing machine interface and the mobile application
- The smart grid function, the overwashing reminding, also the HOMIE bag, can be more proactive to inform the user in advance so that they have more chance to adjust their washing behavior.
- Reinforce the benefits of sustainable behaviors for "Eva"s, try to absorb them more.
- More contexts of washing, for example, washing the different types of fabric like towels and sheets can be explained with the concept, for now, users are wondering what will happen if they choose 60 degrees for washing things which should be washed under that degree.
- On the washing finish page, the sentence "4 times left to wash" is not so clear to the user, they feel like after 4 times the washing machine won't work which is not true.







Final Design

In previous chapters, the intervention concept is iterated with user tests. This chapter the final concept HOMIE Lifestyle is demonstrated. The concept is explained, followed by the main user flows with different personas.

9.1 Final Concept

9.2 Desired User Journeys

9.1 Final Concept

The final intervention concept is made up of 4 main components, the HOMIE loading bag(1) for measuring the loading amount of clothes, the washing machine interface(2) for giving the personalized real-time sustainable feedback, the mobile application(3) for keeping motivating the sustainable behavior and the personalized real awards(4) which are consistent with the game users choose for rewarding the sustainable habits.



Real-time sustainable informationshown in tree growth



Real-time sustainable informationshown in money





HOMIE Loading Bag

With the transparent bag, the user could know the mini and max amounts of clothes for each washing, therefore to optimize the energy, water and detergent consumptions.



Washing Machine Interface

With the support of IoT technology, the washing machine could recommend on the program, put the detergent automatically, and optimize the washing schedule.

The interface shows the sustainable information in a meaningful way for the user to step into user's laundry setting decision making to be more sustainable.



some time later



Grow your forest





Mobile application

In the application, the user can check how benefits are accumulated with their sustainable behaviors in the way they choose, also their impact on the environment. By the various stimuli, for example, the forest growing, medals, and real awards, the user can be motivated to keep behaving sustainably.



Personalized Real Awards

When the user behaves sustainably for a period, they will have the chance to exchange for the real awards to reward their positive environmental impact. The award they can exchange is consistent with the game they choose before. For the tree planting, they can have the seeds or pot plants while for the money saving they can get coupons.

9.2 Desired User Journeys

Considering the different behavior patterns of different personas, the chapter will demonstrate the two user flows: tree planting game and money saving game across all platforms.

Greene's Tree Planting Journey



Greene is a sustainable person who will consider the environmental impact in his daily life, and is willing to try new things that are beneficial in the sustainability.

He is going to wash tshirts, pants today with HOMIE washing machine.

1. Check the washing habit

Greene behaves better than Dutch average in the similar group, he decides to catch up with the best with the information shown

2. Choose the game

Greene thinks plant the tree is good to the environment, so he chooses to grow one, and gives the name.

3. Load the clothes

Greene knows he has full load the machine with the help of HOMIE bag, he puts them in the machine and waits for the mechine to recommend a program









with the iDOS sensors, the washing machine detects the clothes and gives the advised program and puts the detergent automatically based on the clothes materials.



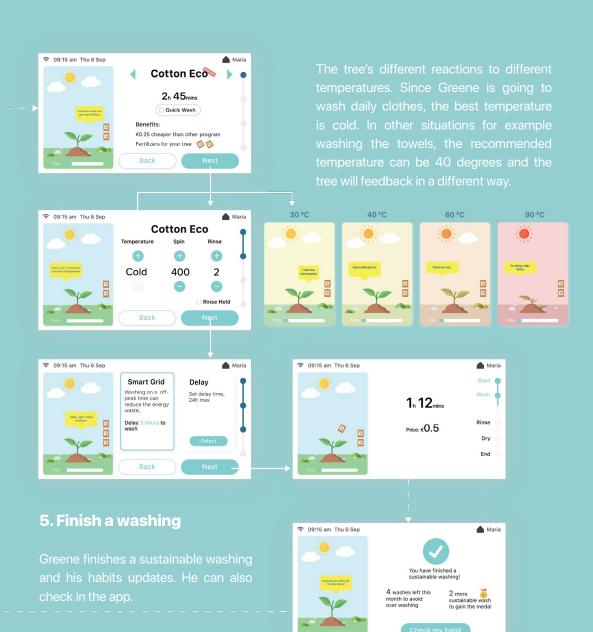






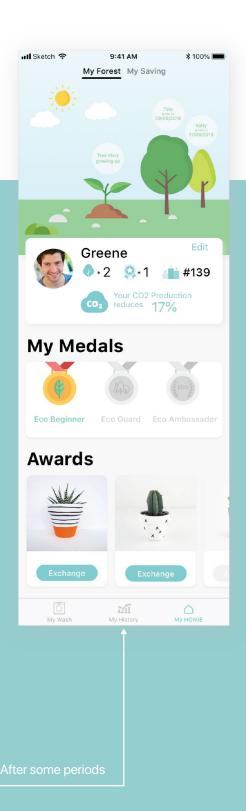
4. Finish washing settings

The machine recommends on Cotton Eco, Greene chooses it because it gives fertilizers to his tree as well. Then he sets the cold temperature, the smart delay time by considering the tree's









1. Check the washing status

Greene checks the washing status with the app, and remote control to turn on/off the machine. The machine can send the notification to Greene whether it's the energy off-peak time

2. Check washing habit

Greene could also see his habit suggestions on behavior improvements and hills in the app

3. Greene's forest

After sustainable washing for some time, Greene grows his first two trees successfully, and gains the medal He is happy to see his CO2 emission decreases.

He is now able to exchange some rea awards, but he wants to grow more trees



.........





4. Plant a new tree

Autumn comes, Greene's third tree is almost grown up, so he can now choose the next tree to plant in the app.

5. Choose your tree

Greene sees the Christmas tree in the list, he chooses it because he wants to have it around the Christmas days. Also, he will continue behaving sustainably to unlock more trees to decorate his own forest.

How does Eva Save Money in the Meantime Save the Planet



Eva is a person who doesn't pay too much attention on sustainability, but is willing to change.

She just fills the HOMIE bag with towels and sheets, then she receives the notification of energy off-peak time, so she decides on washing them with HOMIE washing machine.

O. Receive the notification of off-peak time

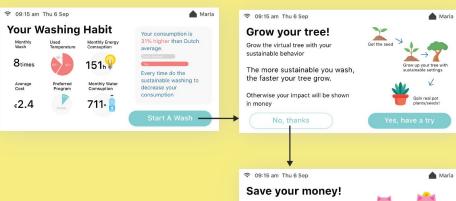
Now is the energy off-peak time. Would you like to wash your clothes now in a cheaper price?

1. Check the washing habit

Eva consumes more than Dutch average in the similar group, she feels unhappy to know that and wants to improve

2. Choose the game

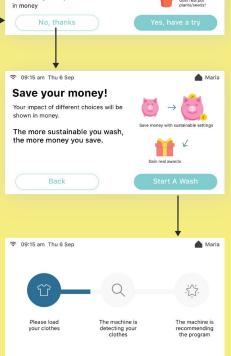
She chooses to save money since she cares about money and wants to save.



3. Load the towels

Eva puts the towels and sheets in the machine and waits for the mechine to recommend a program

With the iDOS sensors, the washing machine detects the towels and sheets, and gives the advised program and default temperature, then it puts the detergent automatically.









4. Finish washing settings

The machine recommends on Cotton Eco and 60 degrees, Eva usually uses 90 degrees for sheets, but seeing the amount of money, she decides on choosing 60 degrees.



60 ℃

Price: **€1.7**5

400

2

Rinse Hold

Price: €2.25

The cost is compared by with Dutch average in the similar user group and similar things to wash.

The piggy bank shows different numbers on the savings to tell the user about their impact.











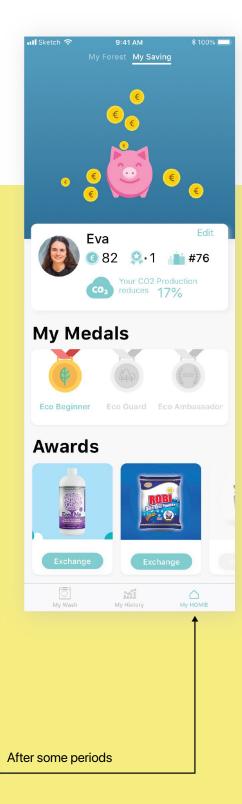
5. Finish a washing

Eva finishes a sustainable washing and her habits updates. She can also check in the app.









1. Check the washing status

Eva checks the washing status with the app, it is now washing, and she can stop it remotely with the app.

2. Check washing habit

Eva knows more about her habits and behaviors with the charts, she can then behave better with the suggestion.

3. Eva's saving

Every wash Eva chooses to be more sustainably so until now she has saved a lot of money, and make the contribution to the environment as well. She is glad that she can exchange the detergent by sustainable decisons, she will then strive for the next award.

Conclusion

10.1 Project Conclusion

10.2 Recommendations

10.1 Project Conclusion

The goal of this project is to explore what IoT supported interventions regarding the washing machine interface can stimulate the sustainable washing behavior under the "Pay-per-use" business model.

Initially, three research questions are came up with to define the scope of this project. The first question is "What are HOMIE's expectations and possibilities regarding the sustainable intervention?". The literature review, company research, and IoT products benchmark are conducted to answer it. The result shows that HOMIE is expecting to integrate the intervention on the washing machine interface to provide a real-time feedback to the user due to the inappropriate timing of the current intervention email before, which leads to a little effect on sustainable behavior stimulation. Successful cases of other washing machine brands and IoT products indicate that the conjunction of various sustainable intervention strategies and more IoT capabilities can be effective in changing user's behavior and in the habit formulation. Therefore, HOMIE can extend the smart function of the washing machine on spurring the sustainable user behaviors.

The second research question is "What are the users' behavior patterns when they interact with the washing machine?". It is answered by the user research. The top concern of the laundry process is the cleanliness of the clothes. Generally, users have no clear impression on sustainable washing, yet no clue on their own impact. Users don't about the sustainability during the washing process but they are willing to behave in that manner if the intervention is effortless to use and won't step into their normal process. However, due to the lack of sustainable information, users have no motivations to change their behaviors.

The last research question is "What IoT supported user interventions can HOMIE use to stimulate sustainable usage?". Based on the results of previous questions, the challenge is to meet user's normal usage desire in the meantime stimulate the behavior change. Concluded from the creative sessions' insights and findings from previous research, create the meaning to the user can create their motivations on sustainable change while using the smartness of IoT to balance the complexity of the intervention. As a result of concept ideations and iterations, the final design integrates the intuitive experience of IoT, the personalized meaning and microinteractions to step into user's decisions during the interactions with the washing machine.

As the final intervention design concept, the washing load bag, the washing machine interface, the mobile application, and the real award services work altogether to achieve the goal of sustainable washing behavior stimulation and sustainable habit formulation. Eventually, the evaluation shows that despite the limitations, the interventions are of good usability and effective in sustainable behavior change, which proves the design challenge is well balanced.

10.2 Recommendations

Related to limitations of the project which were presented in the previous chapter, recommendations for further research and design include the following points:

More test with different age user groups

As mentioned before, due to the access limitation of the author, participants for both the interview and user test are mainly Millenials, who hold similar attitude and are similarly capable of accepting new concepts than other groups, thus the result of the research can be biased with the limited group of users. Since HOMIE is not restricted in the customer's age and provides the service to all their customers, the test with diverse age groups is of necessity for the future research.

Test with real user for a period of time in the context

The second recommendation regarding the user test is to test in the real context with the end user in a period of time. For this project, due to the time limitation, the test is conducted in a short time and mostly the question related to long-term behavior is only asked by the interviewer and answered by the participant. Therefore, the result is limited because participants are predicting their behavior, not really act. So in the future, the long-term behaviors should be observed and recorded for a more accurate research result.

More scenarios of the application for the long-term engagement

This project considers the long-term engagement of the user for the sustainable habit fostering, by providing sustainable information in a gamified way. But it's just the starting point of the exploration and only introduces basic scenarios and flows. Later more scenarios and journeys can be researched and designed to continually stimulate the user in the system.

The intelligent updates after the user has fostered the sustainable behavior

The aim of the intervention is to stimulate sustainable user behavior. So that the effect of stimulation can fade with the improvement of user's behavior. Then there is no need for interfering with the user of their behaviors. With IoT capabilities, it's able to make the system smarter to make the decision and the process simpler when the user already behaves sustainably.

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