

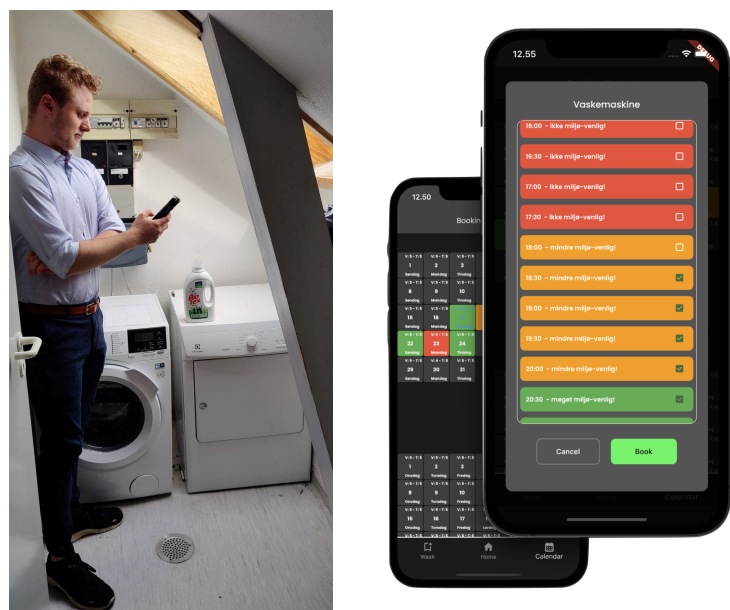
Shifting laundry behavior towards sustainability with Washee

JAKOB SKOV SØNDERGÅRD, 20186311, Aalborg University, Denmark

RASMUS HENRIKSEN, 20181979, Aalborg University, Denmark

MARCO KLAUSTRUP JUSTESEN, 20194454, Aalborg University, Denmark

MARTIN BRUUN MICHAELSEN, 20124931, Aalborg University, Denmark



Abstract

In this bachelors project, the Washee system was developed to test whether laundry behaviour could be shifted towards a more sustainable environmental behavior in a communal laundry setting. The study focused on how presenting environmental sustainability information through a system, where tenants of an apartment complex could book laundry times from their mobile phones, would impact their laundry habits. The study ran for four weeks collecting baseline data from the five active participants for two weeks, and treatment data for two weeks, where the environmental sustainability information was shown to the users represented by colors green, yellow and red. Based on the data collected and participant interviews we concluded that making our users aware of their environmental impact is not an easy task, but it may affect their laundry habits.

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1 SUMMARY

This bachelor project contains a study in the wild researching the effects of nudging laundry behaviour. This means making users shift laundry habits only by presenting them with color coded environmental information, and without otherwise restricting their choices.

We have designed and implemented a system for logging washing behavior in an apartment complex consisting of eight apartments and 11 tenants. Our system worked as a replacement for an old standard coin-based laundry rental system commonly used in communal laundry rooms.

The paper dives into other related work in the field of shifting laundry behavior towards sustainability. We primarily found studies focusing on how private households shift their laundry activities based on different nudging techniques such as monetary incentives, environmental impact information and technology add-ons in the laundry room. Furthermore, we take into considerations the findings and experiences of this related work and extrapolate them for our own study in a communal laundry room setting.

The system is designed and implemented in an attempt to answer the following research questions:

How will the participants change their laundry behaviour when presented with information regarding the environmental impact of their use of laundry machines? How do they change their perception of doing laundry, when presented with this information? And what insights can be gathered to make improvements of a system supporting sustainable laundry behaviour?

The system is a cyber-physical system consisting of a mobile application, a backend server and a laundry room controller. The backend was used to store and manage bookings as well as storing the users data. The laundry room controller was used to turn on and off the power for a laundry machine, and serve as a lock. The app was used as the UI for the system where users could book a time for when they wanted to do their laundry. The app was able to communicate with the laundry room controller and the backend, and served as a middleman between the two. The user interface was inspired by ideas from other studies which also implemented coloring and was well received by the users.

We designed and conducted an exploratory in the wild study over the course of 4 weeks, that explored the possibility of the participants changing their behavior towards making choices based on recommendations shown to them in the app. The study was split into two parts, a two week baseline to observe their behavior without nudging, and a two week treatment period, where we would attempt to nudge the participants towards greener time periods. To attempt to change the participants behavior we displayed information of the environmental impact of doing laundry at every hour of the day through our app. We found that the participants were happy with the digitalization of their laundry room in particular with the possibility of booking a laundry time. Participants also came up with suggestions for other interventions that might work such as strengthening the economic incentives or using gamification. Of these, gamification was regarded as being more likely to succeed in other studies, compared to economic incentives. We found that presenting environmental information alone was not enough for shifting our users' behaviour. However, there were other benefits from implementing the system such as getting rid of the need of having cash available for the coin-based system. Moreover, the participants really enjoyed having an overview of when the machines were actually available which allowed them to book the machines accordingly. The study creates a foundation from which the Washee system can be further developed which could grant plenty of possibilities for presenting information about sustainability impact in various ways.

2 INTRODUCTION

According to multiple studies good laundry habits can assist in improving the environment [4, 8, 9]. When transitioning into a society with an increased dependency on renewable energy, energy consumption needs to be dispersed as evenly as possible over time for the system to be efficient [8]. Laundry machines use up a large amount of electricity, but fortunately they are not time-critical appliances and thus it is beneficial for the environment if everyone were able to shift laundry hours for better suiting the demands of the grid. Using a communal laundry room can significantly reduce the carbon footprint between a 29% to 35% reduction in multi-family housing, due to factoring in the reduction in material consumption needed to produce machines [12]. Making it more appealing to use a communal laundry room in combination with shifting behaviour could therefore be a significant contribution to the UN's global goal 13 of taking responsible climate action [10].

However, the use of communal laundries have declined, as buying a privately owned washing machine has become increasingly affordable, making for so called "washing towers" with a washing machine and drying machine stacked on top of each other in a private home. Tenants do, however, still prefer this setup over a communal laundry room, since they simply are more easily available, making it easier to schedule your time. [6]

When you have your own machine(s) it is more convenient to do your laundry and plan your laundry activities. You can do laundry on your own time and potentially decide whether or not you would like to change the laundry activity from one time period to another, regardless of when others should decide to do their laundry. The notion of changing time periods for doing laundry is an integral part of this paper, as it presents a way for people to do their laundry when the power grid is supplied by wind, solar or hydro power, thereby reducing the use of non-renewable energy sources.

Today, some people still do not own a washing machine or a dryer in their household. Most people who do not own such appliances mostly reside in apartment complexes where the go-to option is a common communal laundry room where all tenants share the same number of machines. A vast majority of the studies we could find which looked at changing laundry behavior, focus on the private household and not so much on the shared communal laundry setting.

This paper uses the concept of nudging, meaning we try to alter participant behaviour without restricting their choices or altering their economic incentives, as presented by Caraban et.al. [3]. We made an exploratory in the wild study of how users can be nudged to make better environmental decisions for when they do laundry in a communal laundry room setting. We do this by providing tenants in an apartment complex building with a smartphone app that allows them to book time slots for the shared laundry machines based on when its environmentally sustainable to do their laundry. The bookings are then enforced through a cyber-physical system that controls the power-connection to the machines. The study involved 11 tenants across 8 apartments and the study was conducted for 4 weeks in total.

3 RELATED WORK

In this section we will dive into different studies and their respective research on the challenges and benefits of nudging people towards making decisions that are deemed healthy for the environment within the area of doing laundry.

3.1 Financial Benefits

As Kobus et. al. [9] shows, financial benefits are often a valuable mechanism for changing behaviour. However, because electricity is relatively cheap it can be exceedingly difficult to achieve a substantial financial gain by circumventing undesirable washing times during the day in regards to the environment. The hassle of completely changing one's plans to accommodate a more "green" time period is often not worth the minimal financial benefit. Moreover, the information

consumers receive of their electricity spending is often aggregated and displayed in the form of an annual bill whereas more direct feedback would potentially be more measurable and provide more value to the consumer[9].

3.2 Plan ahead with a Booking System

Another study done by Enrico et. al. [4] deployed an agent-based interactive system which would allow 10 households in the UK to book time slots for their washing machine such that the agent could help to minimize the cost of doing laundry by charging a battery when the price was cheaper. The system included a slot booking interface for scheduling washes; a software agent that monitors and predicts the price and charges the battery when the price was cheaper; and a notification system that would notify the users when the price changes. The interesting part of this particular study is the booking system. The booking system would display a 7-day calendar with time slots for everyday and apply a color ranging from green, to yellow to red - indicating low, middle or high prices. Besides this, the booking system also displayed the raw price indicating what the price would be if no optimization was applied, making the financial benefit more tangible to the user. The team concluded that laundry is a suitable activity for shifting in response to real-time pricing and a well-organized overview of these prices. However, the actual booking of time slots can be difficult for people to align with the uncertainties of their everyday life. [4]

3.3 Sustainable Information

Several studies have shown that families in private households are inclined to shift their washing behavior when presented with information about when to wash in regards to being more sustainable. Kobus et. al. [9] installed an energy management system (EMS) in 24 households with the research objective to see that if the households were presented with information about the best times to wash, they would change their behavior. Through solar forecasts, the EMS would inform the households about the best possible start time of doing their laundry. The researchers found that almost every household ended up changing their laundry behavior to time periods where the laundry would be sustainably supplied by solar panels. Thus highly indicating that if people are presented with valuable information about sustainability they are inclined to act thereafter.

The above is also supported by Bourgeois et. al. [2] who applied four different intervention methods on 18 households for several months. Out of the four different intervention methods one provided proactive suggestions informing the participants of the best times to do their laundry for the current and next day. The participants received these suggestions through SMS and all reported that such information was more valuable than real-time information, allowing them to plan and book ahead. The study also used an intervention method which was coined "contextual control". This method included a tablet installed next to the washing machine as a way to replace the control panel of the machine. The tablet would display the best time to do laundry for the given day and allow the user to choose that time for their laundry in which the washing machine would start on that given time. Alternatively, the user could set "earliest" and "latest" time limitations and the system would pick the best time slot within those limits. At all times could the participants override the tablet and simply start the washing machine if desired. [2]

A similar study to the above was conducted by Jensen et. al. [8] where they installed a physical old-school box equipped with a digital 12-hour clock on top of the washing machine for four families. This study sought to shift behaviour through provocative disruption of existing habits. The clock on the screen would show the next 12 hours, where each hour would be either green or red depending on how much wind energy was expected in the grid. The

Box, as they called it, would disconnect the washing machine from its power source when the clock was in a red time slot and make the machine available when it was in a green one. To power on the washing machine in a red time slot, the families had to press an emergency override button. As an additional nudging mechanism, the team implemented a savings account that would deduct money when the families chose to wash in a red timezone and the money they would normally spend on electricity was then added to the account when washing in a green timezone. This additional feature allowed the families to be more aware about not only being sustainable, but also the economical benefits. The findings of "Washing with the Wind..." indicated similar results to the previous mentioned studies. Some people were very intrigued by the possibility to "beat the system" and only wash during green times. Others did not care much about the financial gain and were only interested in being sustainable. Just like other studies of its kind, family homes are shaped by routines and social norms that affect how people consume energy. The study did, however, confirm that with the right motivation washing behavior can be shifted. [8]

With all this in mind, it is still difficult to determine whether or not the display of sustainable information have a long lasting effect. An analysis of 12,000 households in 11 OECD countries shows that presentation of non-price instruments presenting green information labels when buying products had a positive impact on consumer behaviour in regards to electricity and water usage [5]. However, a study in Belgium suggests that only presenting information is not enough, since 40 volunteer households that got a full energy check to get recommendations in how they could optimize their energy efficiency, only implemented an estimated 11% of those recommendations after a year [1]. This suggests that presenting information itself might not be enough, but should be embedded in a social practice that support the desired behaviour.

Based on the above related work and their respective findings it is evident that people are perceptible to various types of nudging when it comes to their washing habits and behavior in a private household. People living in private homes have certain schedules and routines that, at times, can be difficult to interfere with. We would like to understand how people living in a communal setting where laundry is no longer a private affair in the household, but rather a shared activity that needs planning and scheduling, can be nudged into shifting behavior.

4 RESEARCH QUESTION

As presented in section 3, a variety of studies have been conducted looking at how private households can be motivated into choosing more sustainable time periods for doing their laundry activities. Whether it be through monetary benefits [4, 9] or nudged by presenting sustainable information to the user [2] [8]. All of these studies are insightful to understand how a private household can incorporate smart technology that combined with incentives and information can lead to behavior change that ultimately can lead to a potential reduction in carbon emissions. However, all of the presented related work have one core thing in common: the setting. All the studies have installed some technological device in a private household with a private washing machine and conducted their studies within those four walls, respectively for all participants. But as noted in section 2 using a communal laundry room can reduce carbon emissions substantially and at the same time proposes a much more challenging environment to affect change. In a communal laundry room setting, tenants would not have access to the machine(s) unconditionally, but rather needed to plan, schedule and book their laundry activities to avoid clashing with other tenants. Scheduling in such an environment is more challenging

than in a private household where the machine is always available. Participants could end up dismissing the best possible time slots for the environment because of unavailability and inconvenience.

In this paper we are researching how presenting green information in a communal laundry room setting can support environmental sustainable behaviour. Through this we can contribute to the knowledge base surrounding whether presentation of information is a feasible way to increase consumer perception of their own energy consumption, as well as seeing if it has some immediate consequences to their laundry habits.

Encouraging green behaviour is paramount to achieving the Global Goals set forth by the United Nations, related to tackling the climate crisis. Given that this issue can be solved by increasing the use of sharing available resources, this project focuses on how behaviours can be shifted in communal laundries, giving us the following research question:

How will the participants change their laundry behaviour when presented with information regarding the environmental impact of their use of laundry machines? How do they change their perception of doing laundry, when presented with this information? And what insights can be gathered to make improvements of a system supporting sustainable laundry behaviour?

To answer the problem statement this project will make a live study in an apartment complex with eight apartments consisting of 11 study participants, spanning four weeks. The study will be a two week baseline, where data will be gathered on how the participants will use a new digital system compared to the coin-based system already installed in the laundry room. The two following weeks will serve as the treatment, where the study participants will be presented with environmental-impact information, without changing the price. During this, the participants will be interviewed before the study, in the middle and by the end of the study. The details of how this study is structured will be presented in section 6.

In order to conduct the study there was a need to develop and implement a digital solution that could replace the coin-based system in the laundry room. This new digital system needed to accommodate a minimum of expected requirements, in order to be tested in a live setting. It should also implement valuable features to the participants, in order to increase their engagement and participation in the study [8].

Since the digital system works as the base from which the study can be conducted, the design of the system will firstly be presented in the next section 5.

5 DESIGN OF WASHEE

To conduct our study, we created a cyber-physical software system called **Washee**. Washee is built to be an inexpensive system that eases the renting and usage of laundry machines in communal settings, to aid users in shifting their laundry habits toward being more environmentally sustainable. Washee assists the study by collecting laundry-habit data and is responsible for presenting users with the information regarding the environmental impact of using laundry machines at different times. As part of the design process, we conducted preliminary interviews, appendix C.5, with the participants in order to get feedback on their experience of using their existing coin-based system together with their problems in using it and ideas for potential improvements.

The overall structure of the system can be seen in fig 1

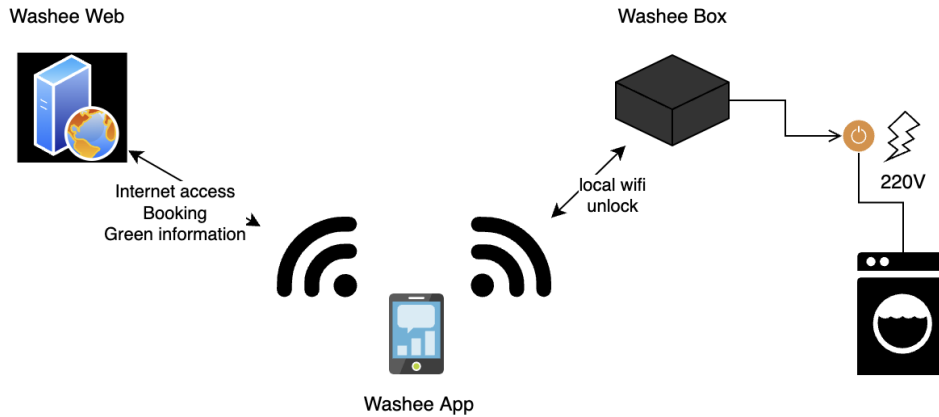


Fig. 1. The Washee system connected to a washing machine

As shown in figure 1 the Washee system had three main components: the **Washee App**, the **Washee Box** and the **Washee Web**. The app is used by the participants and can connect to either the Washee Web backend or Washee Box installed in the laundry room, not both at the same time. When connected to Washee Web it can update the state of bookings and get the green information, which describes the environmental impact of using laundry machines at different times. When connected to Washee Box the app can turn on the power for the machine by getting the Washee Box to switch on a relay.

The Washee App is the entry point for the user to interact with the system. It enables the users to receive green information, create bookings and, from the laundry room, unlock the booked machines. To create the app we used **Flutter**, which made it possible to develop one app which works on both Android and iOS, which were the operating systems used by the participants.

The Washee Box is what connects the app to the laundry machines. As a cyber-physical system, Washee Box can control the power supply to the laundry machines. The Washee Box is controlled from the app, however only through local wifi, since there generally is no internet in most laundry rooms. This was the case for the laundry room used in this study. Washee Box uses **python** and implements **flask** as a REST API, to communicate with the app.

The Washee Web is also written in **python** and implements **Django** for communicating with the app through a REST API. Washee Web manages authentication of users and authorization to unlock a washing machine as well as managing requests from the application and storing data in a database.

The database was made using **PostgreSQL** with the ER schema presented in figure 2.

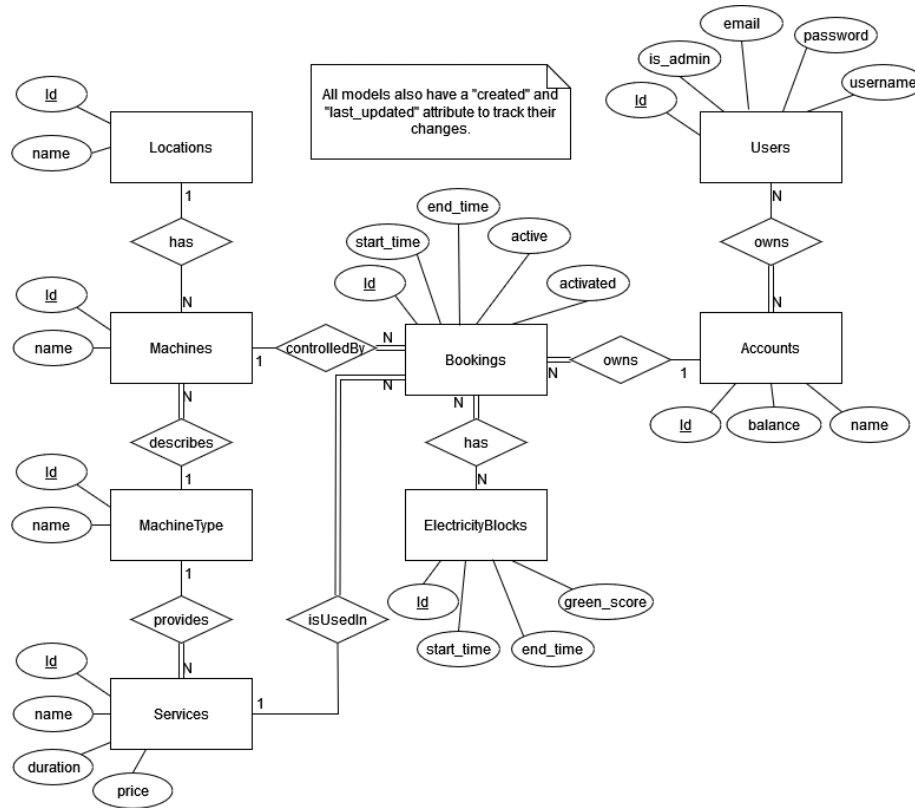


Fig. 2. Database ER diagram

As can be seen in figure 2, the booking consist of four primary relations. It is related to the machine being booked in a specified location and the service being used on the specific machine (wash or dry), which is defined by its type. An account also have to pay for the booking and the electricity block model describes the amount of green energy which is in the electricity network at a given time, making it possible to calculate environmental impact of the booking. The different models can be expanded with further attributes, but only the ones necessary to conduct the study have been included.

After the system was deployed we constructed a State Machine model using the tool UPPAAL, to investigate which pitfalls and challenges our design might have as a cyber-physical system. Given the assumption that the structure of the model and the systems source code is a one-to-one correspondence, and is tested accordingly, then the following characteristics would with great certainty apply to the Washee system. Using this model we proved that the activation of a machine can only happen when it has been previously booked by a user, and that a machine can only be activated after payment has been received. We discovered that the design in which Washee Web and Washee Box only communicates through the app as middlemen, lead to some issues when connectivity was lost to the backend during an unlock operation.

5.1 Features

The features that we planned to implement were based on different requirements from the stakeholders and requirements needed to conduct this study, with inspiration from several studies described in 3. A feature is defined as something the user can do using the system.

The planned features fall into four categories:

- Features **essential** to the base system
- Features based on the **business owner stakeholder**
- Features based on **tenant participants**
- Features based on **what was needed to complete our study**

The unlock feature **essential** to make the baseline system work, was the ability to register and constrain access to activating a laundry machine in a given time period. This feature was the absolute minimum requirement for the system to be a replacement to the coin-based rental system.

The payment feature based on the **business owner stakeholder** requirements was the ability to receive payment for a completed service. Before we could process a payment we needed to have a representation of users and their accounts. The user and its account are separate to make it possible for two users to share an account, for instance if they live in the same apartment. This led us to implementing a login feature where the users could login to their account, and see their account details on the home page.

Based on the preliminary interviews C.5 we found that the users would like the following functionality in the application, presented here in sorted order.

The features based on the **tenant participants** were:

- **Booking of the washing machine** This included the ability to create, delete and display bookings of machines in the laundry room. It also meant that the previously mentioned unlock feature had to be restricted to only allow unlocks on booked machines from the given account.
- **Display of whether a washing machine is in use** This was the ability to see if a machine is currently running.
- **Receive notification when a washing machine is free** This was a feature where a participant could put themselves on a waiting list for specific times or days, if they were occupied.
- **Automatically connect to the laundry room's local wifi** This was in opposition to being set to manually switch between the Washee Box and Washee Web.
- **Receive notification when my wash is done** This meant receiving information when the laundry was done.
- **Automatic log in when I start the app** This removed the need to login apart from the first time the app was used.

We implemented the most wanted features first, booking and display of machine in use, however automatic login and automatic wifi connection had easy solutions, and were implemented as well. The notification features needed too much effort to be implemented in the given timeframe.

The feature of **what was needed to complete our study** was to tell users which time-slots would be the most environmentally friendly. This was the feature this study would closely monitor, to answer the research question described in section 4.

During the baseline of the experiment, the time-slots were designed to be gray with pictograms and text denoting the state of the time-slots (available, occupied or selected). With inspiration from the studies presented in section 3 we designed the app to present the users with green information shown as colors with accompanying text on the time slots

when the treatment began. We implemented this together with the booking feature in a booking calendar style using heat-map colors green/orange/red. This had a text describing and colours indicating if the time is highly/moderately/not environmental friendly to do laundry. This was inspired from another study, where the same color scheme related to high/moderate/low price instead of environmental impact [4]. The graphic interface of colors, resembling a heat-map, was very well received by the participants of Enrico et. al. [4]. Because participants of the study indicated that the heat-map coloring made them more aware of certain time slots and also helped them be more organized, we chose to implement a similar style of coloring to promote environmental awareness. (We refer to these as **the colors** when applicable throughout the rest of the paper.)

5.2 User Interface

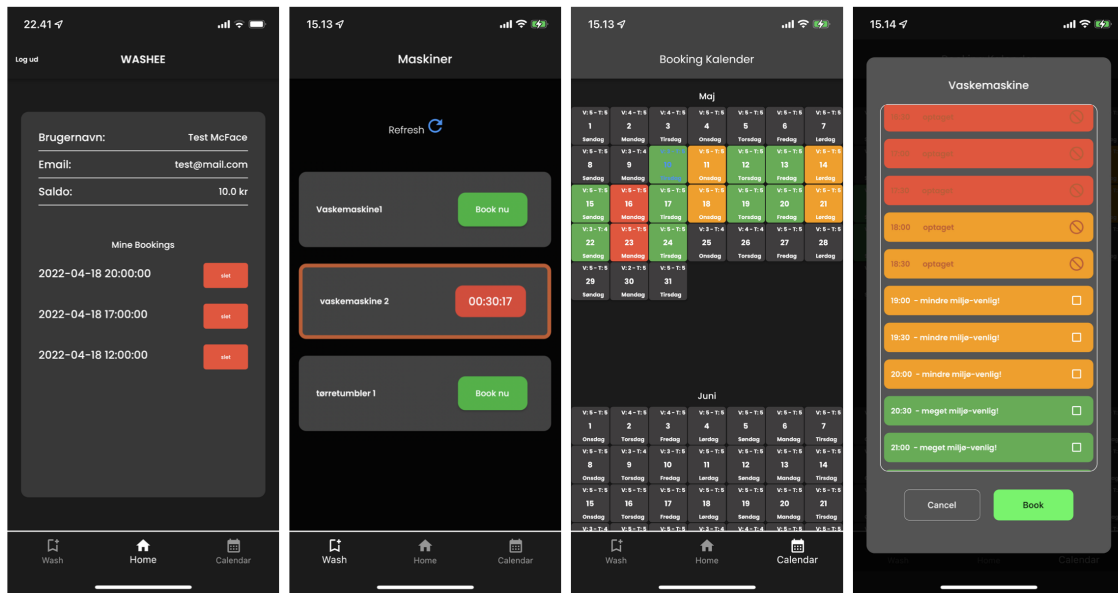


Fig. 3. The entire UI, 1) home screen with bookings; 2) available machines one booking running; 3) booking calendar showing best sustainable time per day; 4) time picker with color-coded booked and available time slots

Based on the feedback from the preliminary interviews with the tenants, we programmed the user interface shown in figure 3. This design would accommodate most of their ordered preferences, and at the same time promote environmental awareness through the color coding and wording.

The homepage seen in figure 3 first picture consists of a display showing the current user that is logged in and their balance as well as their bookings. This page supports the following features

- Display user info.
- Display bookings.
- Delete bookings.

According to the preliminary interviews, appendix C.5, a booking system was the most requested feature for the Washee system. The survey showed that most participants preferred a regular calendar, also supported by Enrico et. al.

[4], that could show a month at a time. The calendar view seen in figure 3 third picture consists of such a calendar with wash and dryer times available on each date.

According to the preliminary interview most participants expected themselves to be more likely to be persuaded to wash on a day with a smaller impact on the environment, by simply being made aware of the environmental impact on a day rather than a financial incentive. This coincides with the findings from Kobus et. al.[9] because electricity is relatively cheap it can be exceedingly difficult to achieve a substantial financial gain and is thus not worth the inconvenience of shifting one's washing times. Based on these findings, to make the tenants aware of the environmental impact we added a color and text to each day and hour which would symbolize how environmentally friendly it would be to wash at that day.

It is also through this calendar a booking is made. We designed the system such that the booking system became the interface into planning their next laundry activities and forcing them to be presented with the environmental impact of a given time slot while planning. The calendar is designed to make the user aware of what days have environmentally friendly laundry times and which do not. On figure 3 picture four, the booking time-picker window can be seen. What catches the eye in the time-picker is the colors. It is intentionally designed to make the user aware of what time slots are best for the environment. According to the survey it was important to the tenants that the time was flexible and not in blocks. We have compromised this a little, in the booking window a booking can be composed from 6 desired time slots consisting of 30 min intervals.

The Wash screen, seen on figure 3 picture two, shows the machines of the laundry room. If a machine is booked by the user for the current moment it can be activated by pressing the activate button. If a machine is not booked at the current moment, the user will be redirected to the calendar so they can make a booking. When a machine has been activated it displays a countdown timer stating how much time is left of the booking - see "vaskemaskine2" in the second picture.

With the design in place and implemented, we could start the study, which will be described in the following section.

6 USER STUDY

The Washee system was deployed in the laundry room on the fourth floor of an apartment complex in Denmark and ran for 4 weeks straight. Everyone in the apartments had access to the laundry room and got instructions on how to install the Washee App on their mobile devices, and was instructed to use the Washee system whenever they wanted to occupy the laundry room. All participants were in the age between 20 and 30.

We wanted to study if the participants could be nudged into shifting their laundry times by presenting them with information of their environmental impact.

The owner of the apartment complex required that the system should work side by side with the current coin-based laundromat system in case our system should fail such that it would still be possible for the participants to do their laundry.

We wanted the study to run as long as possible in order to register recurring patterns in washing habits and to collect baseline data during the first 2 weeks of that period.

6.1 Setup

The study was conducted in two parts lasting two weeks each, with the first part being a baseline presenting the system without the colors as described in section 5. During the baseline the participants could familiar with using the system. The second part introduced the feature of showing the user the colored laundry times as described in section 5.1.

With a basic replacement for the laundromat system, we made sure that everyone going into the study would use the booking feature and only use the coin-based system when they had a booked time or in case of the unlocking of a machine would fail. We would check the system each day, with one in our group living close by the apartment complex and making it possible for participants to note when they have used the coin-based system instead of our system on a piece of paper. We also got access to the coins inserted into the laundromat to verify if people did in fact note their use.

We wanted to intervene as little as possible when we updated the app to show the colors as described in section 5.1. For this, we made an update two weeks into the study introducing the colored time slots^{5.1} as the only additional feature.

The schema below shown on figure 4 displays how the time slots from 06:00 till 23:00 have been awarded colors from red, orange to green. The coloring is based on the bookings we collected during the two week baseline which are the black bars shown in the schema.

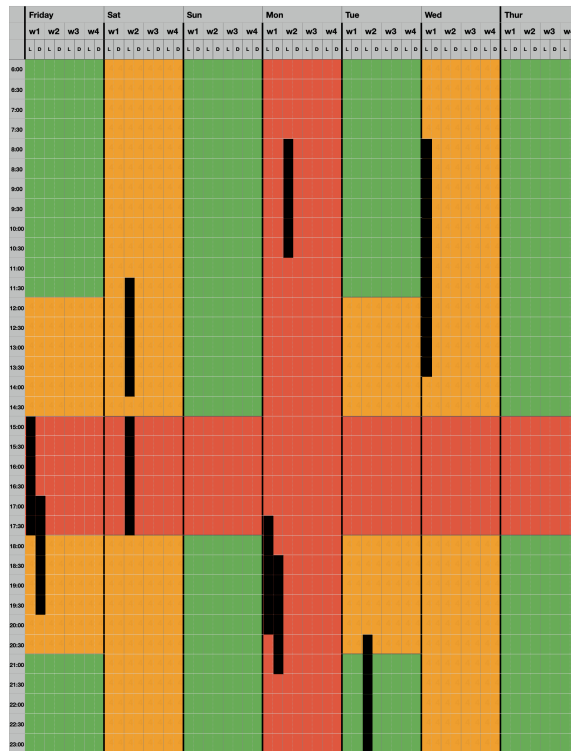


Fig. 4. A schema showing coloring of time slots and registered bookings (black bars) during the two week baseline, large version can be seen in appendix F.1

The schema in figure 4 displays the weekdays from Friday to Thursday in the top row. Each day is associated with four weeks represented as W1, W2, W3 and W4. Each week is associated with time slots for washing and drying; W: denotes Washing machine, D: denotes Dryer.

When deciding which time slots were to be either red, orange or green we based it on the data collected from the baseline. From the data we made the following decisions:

- Red: The red color was given to the time slots from 15:00 to 18:00 which we calculated had the most used laundry times across all 3 hour segments during the baseline. Due to an error where the data was collected in Coordinated Universal Time(UTC) which is 2 hours before Central European Summertime (used by the participants), it should have been 17:00 to 20:00 to represent the most used 3 hour time slots. We deemed This error to have a minimal influence on the study, since we would still be able to detect a shift in behaviour. Monday, which was the most used weekday, was also made completely red. This gave a total of 35 hours and 30 minutes of red time.
- Orange: This color was assigned so that 2 days would contain only red and orange colors, being Saturdays and Wednesdays, and 2 days have a mix of all 3 colors going from red to orange to green, being Fridays and Tuesdays. On the mixed days the red zone was surrounded by 3 orange hours before and after. This concluded in a total of 41 hours of orange time.
- Green: All other times would be green allowing the user to select green time-slots on both convenient and inconvenient times. The green time summed up to a total of 46 hours.

This dissipation of the colors specifically meant, that around the most used laundry time, the user could choose both orange and green time-slot alternatives.

As stated in the list above there are more green time slots than orange and more orange than red (green: 46 hours, orange: 41 hours, red: 35.5 hours). We decided to set the times to red where we expected that people would want to do laundry the most. We did this in the hopes that we could discover a tendency where the participants would try to avoid the red zones. We assumed that if we could register a tendency amongst the participants choosing more inconvenient times (green or orange) and thus avoiding the red zones, that could suggest a will to shift behaviour. The collected data was to be followed by an exit interview addressing the specific bookings.

The participants initially fell into two groups with one group stating they would be able to move three hours and not entire days, the other stating that they would be able to move one day but not three hours in regards to their washing habits (ref section 6.2). This was the main reason we chose the specific three hour parameter for our orange times and made sure it would only apply half of the time. By doing so, it would be measurable if participants in general would move their washing away from red zones.

6.2 Participants

The eleven participants, see appendix A.1, consisted of residents in an apartment complex in a larger town in Denmark. The only criteria for participating in the study was that they lived in the complex and owned a smartphone. The complex contained eight apartments, and during this study we will reference them by their floor and side of the stairs. For instance, 1.tv reference first floor to the left, and 3.th reference third floor to the right, following Danish convention. By installing our system in their shared laundry room on the 4th floor they all became participants in our study even though two apartments had their own washing machine. They were a rather young demographic, with everyone being in the age range 20-30 where the majority was around 24 years of age. Some were students others worked as craftsmen. Five participants lived alone the rest were couples in the remaining three apartments. We did preliminary interviews with five participants, 1.th, 2.th, 3.th and the two inhabitants of 4.tv, during the planning of the study. All the interviewed except 4.tv stated that they believed they might change behavior if they were shown information regarding the environmental impact of their laundry, and that this would weigh more than an actual change in the electricity price, as long as the price would stay within the price range they were used to. The participants fell into two categories: 2.th and 3.th could see themselves shifting their laundry three hours, but not between days, and 1.th and 4.tv could see

themselves shifting their laundry an entire day, but not three hours. All five interviewed participants expressed that their current system was lacking a booking functionality. From their statements we expected roughly 7-8 bookings a week from the eight apartments, given the participants expected to do 1,5 laundries a week, and five apartments were dependent on the laundry room. We also expected 75% of them to be somewhat inclined to shifting behavior as a response towards less environmental impact, given the answers of the interviews.

During the study five apartments consisting of six participants used the system where three of them participated in interviews. Two apartments, 1.tv and 2.tv, already had washing machines, but needed access to the dryer, and 1.th apartment primarily got their laundry done elsewhere.

6.3 Procedure

The experiment began on the 22nd of April where everyone received an email. The email specified the username and password to the app, how to install it on the different devices, explaining who to contact if they had any feedback or experienced problems as well as a guide explaining how to use each feature in the app. After a week, five participants accepted the invite to do a pre-treatment-interview where they could give their feedback as well as answer questions specified in D.1. The interview would validate the user experience of the app and our collected data so far of their laundry habits. After two weeks, on the 6th of May, they would receive an update to the app having the specified coloring scheme implemented. Three weeks after we would invite the same participants that had used the new update at least once to an exit interview specified in E.1. This was necessary to do one week after the update due to time constraints of handing in the paper. On the 20th of May the study was officially over.

6.4 Data Collection

Collection of data was primarily split into two categories, qualitative interviews and quantitative registration of use of the system.

6.4.1 Interviews. As specified in section 6.3, we did a pre-treatment interview leading up to the app update on the 6th of May with the 3 participants that agreed to be interviewed during the study. We also did a post-treatment interview after the update with the same participants, addressing their specific use of the system.

Both the pre- and post-treatment interviews consisted of a fully-structured part and a semi-structured part. The translated questionnaires and results can be seen in appendix D.1 and appendix E.1 respectively.

The pre-treatment interviews' structured part handled feedback on the user experience in regards to the entire Washee system based on the System Usability Scale (SUS) [11]. It also asked questions regarding our interpretations of the data in terms of how normal laundry times and days matched the participants own experiences. The open part of the interview investigated if they had experienced any difficulties when interacting with the Washee system.

The post-treatment interviews' structured part were related to how the participants felt they had been changing behaviour due to the nudging of the system. Moreover, this part would investigate how the Washee system compared to the traditional coin-based system. Also, the questions from the pre-treatment interview regarding user experience using SUS were presented again. The interview ended with an open discussion on specific bookings they had made. We asked about bookings the participants had made in order to get some insight into the participants thoughts and considerations when using the Washee system. We also discussed the future of the system and some of their ideas will be discussed in section 9.

By having the SUS score in both the pre- and post-treatment interviews we could compare if the addition of presenting environmental impact information had any noticeable usability impact. The fully-structured parts of the interviews made the answers of the participants easily comparable, while setting the scene for the semi-structured part.

6.4.2 Registration of use. When participants used the system, their activity was registered. We made it so that all bookings that were created, activated and deleted would be registered.

We also got access to the coin-based laundromat so we could see how many times coins had been used during the time of the experiment instead of our app. Paper and a pen was placed on top of the washing machine, and the users were instructed to register when and why they had used the coin-based system instead.

7 RESULTS

The results from the study is split up into the objective results gathered from the use of the system, the results from the pre-treatment interview and the post-treatment interview.

7.1 Objective data

Figure 5 shows the gathered data of the study. During the course of the study 8 bookings were made before the introduction of the color system (blocks in the white week-columns), whereas 8 bookings were made with the color system (blocks in the week-columns with red, orange and green colors).

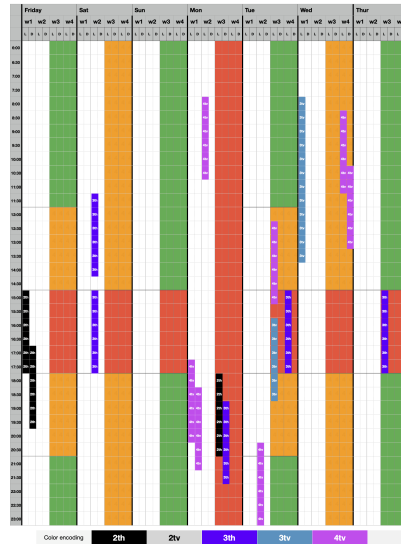


Fig. 5. The data gathered from the 4 week experiment. The baseline columns, week 1 and 2, has a white background. The treatment period - the next 2 weeks after the baseline weeks - display the colors associated with each time-slot from 06-23. Each participant - 2th, 2tv, 3th, 3tv and 4tv - has a distinct color and their bookings are represented by the vertical blocks associated with their respective color. Large version can be seen in appendix F

In the diagram fig.5 we see that in spite of the users expectations from the preliminary interviews, the weekends are not the busiest days, however Monday and Tuesday are used by the majority of the users. Most of our participants do their laundry in the interval from 15:00 to 20:30 but have bookings dispersed over the entire day. During the treatment

the busiest day was Tuesday, and the busiest 3 hours of the days were a tie between 15:00-18:00 and 18:00-21:00 with 17 activated 30min slots in each. During the baseline the busiest day was Monday, and the busiest time of day was 17:00-20:00 with 18 activated 30min time slots, see figure 5 shown in the white columns. Looking at the individual participants, 2.tv shifts from red and orange to entirely red. 3.th shifts from red and orange to mostly red. 3.tv shifts from entirely orange to mostly red and 4.tv shifts as the only one in the expected direction from entirely red to mostly orange. We asked the participants about their considerations for the specific bookings in the post-treatment interviews.

From the data collected, shown in appendix F, we can see that the participants do not tend to plan their laundry time in advance. The bookings are generally created within 30 minutes of the intended laundry time, and when the laundry is planned for the next morning they do the booking the night before. From the data we can see that the participants activate their booked machines and they are on time with a max of 18 minutes delay (column : "time from laundry to unlock"). The delay does not differ whether they have booked 11 hours in advance or 11 minutes.

When looking at the specific accounts in appendix F Data sorted by account, we see that 3.TV never started a machine with the app, but used the booking functionality. 2.TV only placed one booking, and deleted it while the booking was due, she explains this in the pre-treatment section below.

7.1.1 Bypasses. In the pre-treatment period our system was bypassed four times. These were all dryer activations and all originated from the same apartment 2.tv the same apartment that deleted their only booking. This apartment had forgotten to use the system for the dryer, due to having their own washing machine in the apartment.

In the post-treatment period, the machines were used three times outside of our system. These were all made by 4.th, which had not used the system at all during the experiment. Unfortunately we never succeeded in getting in contact with this user.

None of these bypasses of the system did, however, overlap with other participants registered bookings.

7.2 Pre-treatment interviews

The pre-treatment interview was conducted after the participants had used the system for 12 days without the colors. The pre-treatment interview received a SUS score ranging from 77.5 to 90.0, with an average of 83.33. This puts it in a "good" to "excellent" range [11].

Everyone either agreed or agreed strongly that the most common time of doing laundry was late in the evening / early night and in the weekends. However, a respondent said his preferred times were Mondays and Tuesdays. Another respondent said she washed on all available days and only one respondent regularly using Saturdays.

Some participants had experienced minor issues with the app primarily related to the activation of the washing machine, but they were all resolved, and did not stop them from doing their laundry. It was mainly minor bugs and issues that gave rise to nuisance rather than issues that affected their behaviour. During the pre-treatment interviews 2.tv uttered, off the record , that the reason that she did not use the system was, that she had problems first time starting a machine and made a deal with her sister in 3.th that she would do the bookings for her.

When asked what they wanted to change on the app 4.tv suggested "Easter Eggs" (ie. hidden features, games that would become active or similar that given some criteria using the app). 2.th would like to be notified when a machine was finished, 3.th would like to be able to power on the machine from her apartment, allowing her to leave the phone in the apartment when doing laundry.

7.3 Post-treatment interviews

The post-treatment interview was conducted after the participants had used the system for 12 days, with the colors. The post-treatment interview received a SUS score ranging from 75.0 to 97.5, with an average of 84.17. This puts it in a "good" to "excellent" range [11].

Everyone disagreed strongly that they had tried to choose green times. They disagreed strongly that the colors influenced their choice and that the colors gave them appropriate information. They strongly agreed that they had chosen when to do laundry before consulting the app, this is supported by the data showing that they did the booking within 30 min before activating the machine. They also stated that their laundry habits were not extraordinary in the test period. This is supported by the data in the sense that the amount of activated bookings were the same in the baseline and in the treatment period.

The app itself was deemed highly usable, and was in its current state deemed a suitable replacement for the coin-based system. The primary reason given was that they did not need coins to activate the machines.

When asking about their most recent specific bookings, everyone agreed that the current color scheme did not do enough. Everyone did, however, come up with their own solution as to how some changes could have changed their behaviour, being economic incentives mentioned by 2.th and 3.th, better information mentioned by 2.th or gamification mentioned by 4.th. When asked if these proposals would have made them change their laundry on the specific day everyone said that it would not.

8 DISCUSSION

In this section we will discuss our findings. We will answer our research questions described in section 4, while discussing related bias in relation to the conditions related to the study, as well as how these findings relate to other studies. We contribute to the field of shifting towards green behaviour in a communal laundry room setting and summarise the key findings.

8.1 Digitalization of the laundry room

One experience gathered from this study is the possibility of digitalizing the communal laundry room such that it creates new conditions and arenas for shifting behaviour towards reducing environmental impact.

The system received a high SUS score from all our interviews, and everyone agreed that a digital system would be highly preferable or at least as good as their current coin-based system. One of the participants said "I am always lacking coins" -2.TH, when asked why the new system was better than the previous one. Also, the feature of being able to see if someone has booked the machine already was of vital importance in why the system was seen as a good replacement. One participant especially said "I am a huge fan of the booking system" -3.TH, and would characterize that as the primary reason why the system feels better to use.

There were, however, some issues experienced during the study that needed to be addressed. Old habits are difficult to change, which became apparent when two apartments forgot to use our system instead of the old coin-based system, because the old system had to be operational during the study. One of them said it was simply because they forgot about the system and "reverted to bad habits" -2.TV.

In this, it is also important to clarify that the study targeted a rather young demographic which might skew these results to make transitioning to a digital system seem easier than if it were to be done with other demographics. Each of the participants did, however, willingly engage with the system, and received it as an offer rather than them being

volunteers. From this, we can conclude that digitalization of a communal laundry room is indeed possible, where conditions for shifting laundry behaviour can be established.

However, utilizing these changing conditions to actually make the participants shift their behaviour proved a much harder challenge.

8.2 Shifting laundry behaviour

During the course of the study there was almost no observable shift in behaviour, and the interviews confirm this.

We assumed from our preliminary interviews that we would have observed at least some shifting towards the greener time slots. This was because all of the recipients agreed that given some information they would change behaviour. After the study was done it was clear this was not the case as everyone strongly disagreed that the environmental information helped inform their choices. This was a general recurrence across all the participants that they had imagined themselves to be moved by information regarding their environmental impact, but they did in fact not do it. As it was stated by 4.TV "You got to wash when you got to wash".

When presented with this information, the participants came up with solutions that might have worked instead. As a general suggestion the idea of a monetary incentive was presented. In the post-treatment interview 2.th said "I might change for 5 kr (1 dollar 7 kr), but 2 kr is too little". This suggestion is rather interesting, given the same person said in the preliminary interview "I do not see saving only 5 kr as a major motivator (to shift behaviour)". When confronted with the question, whether receiving a 5 kr discount would have made him change his latest booking, he also said no, because the time would not allow for it, suggesting the economic incentive sounds good, but doesn't work, at least for 2.th.

The economic incentive was presented as above, as well as gamification and better presentation of information. For gamification, multiple ideas were proposed. An example was a shared digital pet between everyone in the apartment complex, where green actions would improve the digital pet's circumstances, and red actions would decrease them, or as a participant put it "I would be 100% environmental if I could save a polar bear" -4.TV. The participants therefore were highly engaged in the study, and wanted to find ways for making it easier to shift towards green behaviour.

Economic incentives in different ways were explored in Kobus et.al. [9] which found it would be severely difficult to get a high enough economic gain to make the users shift behaviour, mimicking the results we found in our study. Jensen et. al. [8] also had elements of gamification by the use of their Box, where some participants were especially motivated by that element, suggesting it should be explored further.

The last minor observation was how the participants expressed a form of moral guilt. When the questions regarding shifting green behaviour became evident, the respondents expressed this moral guilt as the interview went on: "I know it sounds bad, but I do not really care about the climate, since it does not have a direct impact on me" -3.TH. This sentiment of having to excuse oneself before explaining that they did not use the colors to try and guide their behaviour, was something all participants did.

Experiences from this study can be used to enhance future studies being made in a communal laundry setting.

8.3 Implications for design

Researchers and practitioners looking to find new ways of shifting laundry behaviour, could find some valuable information received from this study. We will present the positive experiences, as well as challenges we encountered.

8.3.1 Simple process is important for voluntary use. One of the areas where we invested a lot of time, was the design of a seamless adoption of the Washee system. Lots of effort were put into the installation, use and monitoring of the Washee system as automated and simple to the participants as possible, with written guides in emails.

Without these considerations, the study would probably not have seen any use at all, since many of the participants were reluctant to invest too much time in setting up their phone, unless they knew exactly what to expect. We also received confirmation from several participants that the written mail was used by them to get confirmation "It was nice following the guide, to check if one was doing things right" -2.TH, even though everyone agreed that the design itself was intuitive.

These experiences have shown that the study and design needs to be encompassed with a broader sense of how to get participants to start using the app in the first place, when having these kinds of in the wild studies, where the use of the system is on a voluntary basis. Especially in this case, since the previous system was working without issues side by side with the new system, meaning more effort had to be done to maintain the participants on the platform.

8.3.2 Participant inclusion is vital. Another area of experience, which lies along the same vein as the previous section, has to do with participant inclusion. By having preliminary interviews, getting to know the tenants in the apartment complex and generally hearing their thoughts, made it possible to create a larger degree of expectation alignment between us and the participants.

This alignment made us aware of what key features had to be done at the start of the study, and which were less important and could be neglected. It also had a visible impact on the participants, where some were asking about the state of the project up till its release, showing a visible change in their engagement.

8.3.3 Benefits of longer studies. Making studies in the domain of laundry was shown to be something that takes weeks. Participants did laundry at most once a week, since they were living only one or two persons in their respective apartments. This made their interaction with the system minimal, having used it at most twice during the baseline and the treatment. It is therefore crucial to invest the necessary time for participants to actually use the system, for it to give any meaningful results.

A benefit of these longer studies, was that we reduced the novelty effect of our system. In the first few days, participants tried all the features, but just in a few weeks they started developing new habits. By designing the system as a replacement of the coin-based system, this also means that the study could in theory be conducted indefinitely, which is in contrast to the studies done in private laundry rooms, where the systems typically are additions to the laundry room, which are not necessary for its operation.

8.3.4 Mobile apps are intuitive for users. We found that a smartphone app was the preferred way of interacting with the laundry machines for these kinds of experiments. Everybody in the apartment complex agreed that having it as an app was a logical way of doing it, and it was an intuitive solution for everyone.

It is however important to clarify that this route had some technical issues. Although we made sure to develop the system in a cross-compatible framework that could target all the participants' different mobile operative systems, we found that one person had hardware problems when connecting to the laundry machines. For this, a mobile app is therefore a good solution, but one needs to be aware of the increased technical issues it might cause. To cope with these issues, it is recommended to make use of different kinds of testing. We had good experiences with unit testing the code, creating a complete virtual development environment of the entire system, and continuous burn-in-testing as well

as end-to-end testing on physical devices. These testing practices caught several problems and prevented them from reaching the users.

8.3.5 Confront users with their own data. The last major implication, was the benefit of confronting users with their own data. Many of our deeper insights in this study, comes from the fact that we were able to present users with their own objective use of the system, and make them reflect on their choices. By knowing participants reflections before, during and after the study, and confronting them with how they have used the system, it was much easier to get a better idea of why the participants did what they did.

9 LIMITATIONS AND FUTURE WORK

While conducting this study there have been several limitations that may have impacted the results of the study. These include the small sample size of participants of the study, and the system had to comply with the apartment complex owner's requirements. In this section we will discuss how these limitations could have affected the study.

As the entire project had a time frame of 4 months, we had limited time to develop the system and conduct the study. This meant that the system that was developed for the study had to be deployed before a certain deadline which resulted in the system still having a few bugs when the study was conducted. This could have possibly impacted the users' behavior. With a longer time frame for development we would have been able to remove most bugs and reduce unnecessary frustration for the users and ultimately get a more precise study. The short time frame also meant that we could only conduct the study for 4 weeks, which is why this was an exploratory study, as the data we could gather would not be able to represent the use of the system in the long run.

The small sample size also meant that the collected data was not statistically meaningful. A study with a larger sample size could be interesting and we could reach a conclusion with more certainty.

The owner of the apartment complex, who we developed the system for, also had their own requirements, that we had to fulfil. The owner wanted the tenants to be able to use the old coin-based system simultaneously with our system in case of issues with our system. This would somewhat increase uncertainty in the data as participants could do their laundry circumventing the Washee system, and avoid any nudging from the app. The owner also had a focus on usability and wanted a system that was at least as easy to use as their old system. This limited our tools as to how heavily we could influence the participants of the study, and meant we could not do anything that would make it harder for the users to do their laundry at certain times. These considerations made the study focus on nudging instead, using non-intrusive instruments.

As future work it would be interesting to experiment with different versions of the UI that would more heavily nudge the users towards making a choice better for the environment. Looking into experimenting with economic incentives, different presentations of the data or gamification for nudging, as suggested by the participants, would also be valuable considerations. Making the system more disruptive should also be considered, given the problems with habits that we encountered.

10 CONCLUSION

In this study it was experienced that presenting information regarding the environmental impact of shifting laundry behaviour had a negligent to non-existing effect. The participants had the initial perception that information would maybe make them change behaviour, but after the study was concluded, everyone did laundry the exact same as before, doing it at the most convenient times regarding their schedule, no matter the information given.

This makes this study support similar findings of other studies, being that just presenting information is not enough. There need to be other external motivators to change behaviour. In this study, the participants themselves proposed higher levels of gamification and economic incentives. Of these, gamification seems as the most suitable to make experiments with, given it was the only one where some of the participants agreed that it specifically could have made them change behaviour in their previous bookings, whereas the two others were seen more as something that hypothetically could change their future bookings.

A side gain from implementing the system is that the users appreciated having a digitalized booking system for their laundry room, seeing it a possible successor to the coin-based system. Logging the laundry activity has presented a possibility of showing the utilization of the machines in the laundry room, discovering what the busy days and time-slots actually are, which can lead to a better utilization of the available machines and a better experience for the users. The Washee system can be developed into a platform that others can use for experimenting with varying UI and evaluate different variations of nudging.

REFERENCES

- [1] Françoise Bartiaux. 2008. Does environmental information overcome practice compartmentalisation and change consumers' behaviours? *Journal of Cleaner Production* 16, 1 (2008), 1170–1180. <https://doi.org/10.1016/j.jclepro.2007.08.013>
- [2] Jacky Bourgeois, Janet van der Linden, Gerd Kortuem, Blaine Price, and Christopher Rimmer. 2014. Conversations with my washing machine: an in-the-wild study of demand shifting with self-generated energy. In *Proceedings of the 2014 ACM International Joint Conference on pervasive and ubiquitous computing (UbiComp '14)*. ACM, <http://mcs.open.ac.uk/JanetVanderlinden/PDFs/Conversations2014.pdf>, 459–470.
- [3] Ana Caraban, Evangelos Karapanos, Daniel Gonçalves, and Pedro Campos. 2019. 23 Ways to Nudge: A Review of Technology-Mediated Nudging in Human-Computer Interaction. In *23 Ways to Nudge: A Review of Technology-Mediated Nudging in Human-Computer Interaction*. Research Gate, https://www.researchgate.net/publication/332745321_23_Ways_to_Nudge_A_Review_of_Technology-Mediated_Nudging_in_Human-Computer_Interaction, 1–15. <https://doi.org/10.1145/3290605.3300733>
- [4] Enrico Costanza, Joel Fischer, James Colley, Tom Rodden, Sarvapali Ramchurn, and Nicholas Jennings. 2014. Doing the laundry with agents: a field trial of a future smart energy system in the home. In *Conference on Human Factors in Computing Systems - Proceedings (CHI '14)*. ACM, <https://dl.acm.org/doi/pdf/10.1145/2556288.2557167>, 813–822.
- [5] To Dieu-Hang, R. Quentin Grafton, Roberto Martínez-Españeira, and Maria García-Valiñas. 2017. Household adoption of energy and water-efficient appliances: An analysis of attitudes, labelling and complementary green behaviours in selected OECD countries. *Journal of Environmental Management* 197, 1 (2017), 140–150. <https://doi.org/10.1016/j.jenvman.2017.03.070>
- [6] Wiktoria Glad. 2021. Laundry power and care: Relational materialism, temporalities and spatialisation of communal laundering. *Geoforum* 127, 1 (2021), 171–179. <https://doi.org/10.1016/j.geoforum.2021.10.019>
- [7] Nielsen Norman Group. 2018. Beyond the NPS: Measuring Perceived Usability with the SUS, NASA-TLX, and the Single Ease Question After Tasks and Usability Tests. <https://www.nngroup.com/articles/measuring-perceived-usability/>
- [8] Rikke Jensen, Dimitrios Raptis, Jesper Kjeldskov, and Mikael Skov. 2018. Washing with the Wind: A Study of Scripting towards Sustainability. In *DIS 2018 - Proceedings of the 2018 Designing Interactive Systems Conference (DIS '18)*. ACM, <https://dl.acm.org/doi/10.1145/3196709.3196779>, 1387–1400.
- [9] Charlotte B.A. Kobus, Ruth Mugge, and Jan P.L. Schoormans. 2013. Washing when the sun is shining! How users interact with a household energy management system. *Ergonomics* 56, 3 (2013), 451–462. <https://doi.org/10.1080/00140139.2012.721522> arXiv:<https://doi.org/10.1080/00140139.2012.721522> PMID: 23009607.
- [10] United Nations. 2022. The 17 goals. <https://www.globalgoals.org/goals/>
- [11] Andrew Smyk. 2020. The System Usability Scale & How It's Used in UX. <https://xd.adobe.com/ideas/process/user-testing/sus-system-usability-scale-ux/>
- [12] Raphael Wasserbaur, Tomohiko Sakao, Maria Ljunggren Söderman, Andrius Plepys, and Carl Dalhammar. 2020. What if everyone becomes a sharer? A quantification of the environmental impact of access-based consumption for household laundry activities. *Resources, Conservation and Recycling*

158, 1 (2020), 104780. <https://doi.org/10.1016/j.resconrec.2020.104780>

A USERS

A.1 User list

- 1.tv
age:
number of inhabitants:
occupation:
He has his own washing machine but no dryer, expects to do laundries 2 times a week over 2 days. He expects to change habits with environmental information and believes he will be flexible in shifting his laundry time by a day.
- 1.th
age:
number of inhabitants: 2
occupation:
she primarily does laundry at her parents place.
- 2.tv
age:
number of inhabitants: 2
occupation:
This person is in family with 2.th and 3.th and has her own washing machine but no dryer.
- 2.th
age:
number of inhabitants:
occupation:
This young man is in family with 2.tv and 3.th. he does 4-5 laundries in one day every week. 2.th expects to change habits with environmental information and expects to be able to shift laundry time by 3 hours.
- 3.tv
age:
number of inhabitants:
occupation:
Has been moving out, left the building during the last week of the treatment period.
- 3.th
age:
number of inhabitants:
occupation:
the inhabitant of 3.th is in family with 2.tv and 2.th. She has been on holiday during the second week of the baseline. She does 8 laundries every week over 2 days. 3.th expects that she might change habits with environmental information, and she expects to be willing to shift 3 hours but not a day.
- 4.tv
age:
number of inhabitants: 2

occupation:

This couple has 4 laundries a week and handles them in one day, one of them expects to change habits with environmental information, the other one does not. This couple expects to be able to shift their laundry time by a day.

- 4.th

age:

number of inhabitants:

occupation:

We did not succeed to get in contact with this tenant.

B INTERVIEWS

B.1 Preliminary interviews (Danish)

C PRELIMINARY INTERVIEW

C.1 Interview 1

Questions:

2.th -> have lived there for 1 month.

- how often do you wash in a week?

4-5 washes once a week (weekends and when i have time (mostly weekends))

- Of these, which are you most aware of on a daily basis?

- -> to save money.
- To protect the environment.
- To wash as few times a moth as possible.
- neither

- [optional] explanation?

Can wait with it, but i never wash 1 tshirt.

- If you were shown information on when it is most environmentally friendly to wash clothes, would you change your washing habits?

- -> Yes.
- No.
- Maybe.
- Do not know.

- How much should you save for washing at a less convenient time?

0-10 kr (expects only low money influence, red / green should influence enough, but would not bother to move time too much) I do not want to change behavior, for instance I do not see saving only 5 kr as a major motivator.

- How satisfied would you be if the price increased at times when a wash will have a greater burden on the environment?

- Very unsatisfied
- Unsatisfied
- -> Neutral

- Satisfied
- Very satisfied

- **How long would you typically postpone your washing if you knew it could protect the environment?**

- 0-1 hour
- -> 2-4 hours
- 4-8 hours
- 8-16 hours
- 1-2 days
- 2-4 days
- 1 week
- 2+ weeks

- **What is most important to you?**

- -> To wash on a particular day.
- To wash at a certain time of the day.
- None of them are important to me.

- **[optional] which days or periods do you prefer to wash clothes?**

Primarily in the weekends, I don't have time in the weekdays.

- **How satisfied would you be if you and other residents could book a washing machine in advance?**

- Very unsatisfied
- Unsatisfied
- Neutral
- -> Satisfied
- Very satisfied

- **Rank these functionalities according to what you would like to see in an application**

2. booking of the washing machine
2. display of whether a washing machine is in use
1. receive notification when my wash is done
4. receive notification when a washing machine is free
3. automatic log in when I start the app
3. automatically connect to the laundry room's local wifi

- **What is good about your current system?**

Nothing to shout hurray for, but it works

- **What is bad about your current system**

Very dependant on me having coins.

- **Which phone do you use?**

iPhone XR

- **Which version is the operating system?**

15.1

- **Additional comments**

When you have paid for a period, you can just as well use it and wash a little extra (possibly an extra shirt or similar that comes with). 2 things in 40 min. still allows for washing of linens for example.

- UI comments

Would prefer to have it say 100 kr instead of 10 tokens.

MANGLER OVERSÆTTELSE Vil gerne have det er et hjul der evt. starter 8:30, vil helst ikke være låst til et tidsrum

Would prefer to have a calendar view where you can then scroll to pick a time.

It should be easy to use. With big buttons and be intuitive.

It should have a confirmation message when you make a booking.

You should be able to delete a booking.

C.2 Interview 2

Questions:

1.tv -> have lived there for almost 2 years.

- how often do you wash in a week?

I do a lot of my laundry at my parents, but i do my own laundry twice a week.

- Of these, which are you most aware of on a daily basis?

- To save money.
- -> To protect the environment.
- To wash as few times a month as possible.
- neither

- [optional] explanation?

- If you were shown information on when it is most environmentally friendly to wash clothes, would you change your washing habits?

- -> Yes.
- No.
- Maybe.
- Do not know.

- How much should you save for washing at a less convenient time?

0-10 kr (I would mostly do it to help the environment, but it would be nice to save a little money.)

- How satisfied would you be if the price increased at times when a wash will have a greater burden on the environment?

- Very unsatisfied
- Unsatisfied
- -> Neutral
- Satisfied
- Very satisfied

- How long would you typically postpone your washing if you knew it could protect the environment?

- 0-1 hour
- 2-4 hours

- 4-8 hours
- -> 8-16 hours
- 1-2 days
- 2-4 days
- 1 week
- 2+ weeks

- **What is most important to you?**

- To wash on a particular day.
- -> To wash at a certain time of the day.
- None of them are important to me.

- **[optional] which days or periods do you prefer to wash clothes?**

- **How satisfied would you be if you and other residents could book a washing machine in advance?**

- Very unsatisfied
- Unsatisfied
- Neutral
- Satisfied
- -> Very satisfied

- **rank these functionalities according to what you would like to see in an application**

1. booking of the washing machine
2. display of whether a washing machine is in use
3. receive notification when my wash is done
4. receive notification when a washing machine is free
6. automatic log in when I start the app
5. automatically connect to the laundry room's local wifi

- **What is good about your current system?**

It is idiot proof, just throw in money and it works.

- **What is bad about your current system**

It is very old fashioned, you cant see how much time you have. It is a bit annoying to have to get coins only for the washing machine.

- **Which phone do you use?**

IPhone 11 pro.

- **Which version is the operating system?**

14.8.1

- **Additional comments** I once experienced that the machine was locked for 3 days, and accidentally pulled off the handle. Other people were mad that there wasn't put up a note about the broken machine.

- **UI comments**

Would prefer to have it say 100 kr instead of 10 tokens.

Would prefer a scroll wheel to pick their time.

Would prefer to have a calendar view where you pick a date first and then pick a time, as to not do it all at once.

prefers the white background, and the design of an app like discord.

Would like an undo button if you press a wrong button.

Easy and manageable, not too much stuff.

C.3 Interview 3

Questions:

4.tv person one -> have lived there almost 3 years.

- **how often do you wash in a week?**

4-5 times a week.

- **Of these, which are you most aware of on a daily basis?**

- -> To save money.
- To protect the environment.
- To wash as few times a month as possible.
- neither

- **[optional] explanation?**

I try to wash as much as i can on a 10, but i also think a bit about the environment by doing a whole wash at a time.

- **If you were shown information on when it is most environmentally friendly to wash clothes, would you change your washing habits?**

- Yes.
- -> No.
- Maybe.
- Do not know.

- **How much should you save for washing at a less convenient time?**

I would not change my behavior to save money, for practical reasons.

- **How satisfied would you be if the price increased at times when a wash will have a greater burden on the environment?**

- Very unsatisfied
- Unsatisfied
- -> Neutral
- Satisfied
- Very satisfied

- **How long would you typically postpone your washing if you knew it could protect the environment?DER
ER INTET SVAR FRA BRUGEREN**

- 0-1 hour
- 2-4 hours
- 4-8 hours
- 8-16 hours
- 1-2 days
- 2-4 days
- 1 week

- 2+ weeks

- **What is most important to you?**

- To wash on a particular day.
- -> To wash at a certain time of the day.
- None of them are important to me.

- **[optional] which days or periods do you prefer to wash clothes?**

- **How satisfied would you be if you and other residents could book a washing machine in advance?**

- Very unsatisfied
- Unsatisfied
- Neutral
- Satisfied
- -> Very satisfied

- **rank these functionalities according to what you would like to see in an application**

5. booking of the washing machine
2. display of whether a washing machine is in use
3. receive notification when my wash is done
4. receive notification when a washing machine is free
6. automatic log in when I start the app
1. automatically connect to the laundry room's local wifi

- **What is good about your current system?**

It is easy and it works.

- **What is bad about your current system**

it is cash based, it can only take 5's, no emergency opening.

- **Which phone do you use?**

Android 1 Plus.

- **Which version is the operating system?**

Android 11

- **Additional comments**

- **UI comments**

Wants to enter it?? manually. WHAT DOES THIS MEAN????

It is better to have a calendar that you can press that will then fold out the time slots.

It would be annoying if you could only see 24 hours forward.

It would be nice to be able to see multiple machines in the same interface, if we had more.

It is dumb to book one hour at a time, when most washes take over an hour.

C.4 Interview 4

Questions:

4.tv person two -> Have lived there for almost 3 years with C.

- **how often do you wash in a week?**

0 times, but i hear about it from C.

- Of these, which are you most aware of on a daily basis?

- To save money.
- -> To protect the environment.
- To wash as few times a moth as possible.
- neither

- [optional] explanation?

We should do more for the environment, but it would also be nice to save some money.

- If you were shown information on when it is most environmentally friendly to wash clothes, would you change your washing habits?

- -> Yes.
- No.
- Maybe.
- Do not know.

- How much should you save for washing at a less convenient time?

I would not change my behavior, it would be nice to save some money, but the clothes still needs to be washed.

- How satisfied would you be if the price increased at times when a wash will have a greater burden on the environment?

- Very unsatisfied
- Unsatisfied
- -> Neutral
- Satisfied
- Very satisfied

- How long would you typically postpone your washing if you knew it could protect the environment?

- 0-1 hour
- -> 2-4 hours
- 4-8 hours
- 8-16 hours
- -> 1-2 days
- 2-4 days
- 1 week
- 2+ weeks

- What is most important to you?

- To wash on a particular day.
- -> To wash at a certain time of the day.
- None of them are important to me.

- [optional] which days or periods do you prefer to wash clothes?

- How satisfied would you be if you and other residents could book a washing machine in advance?

- Very unsatisfied

- Unsatisfied
- Neutral
- -> Satisfied
- Very satisfied

- rank these functionalities according to what you would like to see in an application

1. booking of the washing machine
4. display of whether a washing machine is in use
2. receive notification when my wash is done
3. receive notification when a washing machine is free
5. automatic log in when I start the app
6. automatically connect to the laundry room's local wifi

- What is good about your current system?

We can cheat and wash a lot of clothes for two 5's.

- What is bad about your current system

It locks if you have to change. Sometimes there is a lot of water on the floor.

- Which phone do you use?

iPhone 11

- Which version is the operating system?

15.4

- Additional comments

- UI comments

Prefers a calendar where you click a date which folds out to pick a time.

It would be annoying if you could only see 24 hours forward.

It would be great to see more washing machines in the same interface, if we had more.

Would prefer to be shown tokens instead of kroner.

C.5 Interview 5

Questions:

3.th -> have lived there for 3 years.

- how often do you wash in a week?

About 2 times a week, where i run 4-5 washes pr. time.

- Of these, which are you most aware of on a daily basis?

- to save money.
- To protect the environment.
- To wash as few times a moth as possible.
- -> Neither

- [optional] explanation?

The clothes has to be washed when it is needed.

- If you were shown information on when it is most environmentally friendly to wash clothes, would you change your washing habits?

- Yes.
- No.
- -> Maybe.
- Do not know.

- How much should you save for washing at a less convenient time?

I would no change my behavior, it would probably be in the back of my mind, but i don't think the price would affect me.

- How satisfied would you be if the price increased at times when a wash will have a greater burden on the environment?

- Very unsatisfied
- -> Unsatisfied
- Neutral
- Satisfied
- Very satisfied

- How long would you typically postpone your washing if you knew it could protect the environment?

- 0-1 hour
- -> 2-4 hours
- 4-8 hours
- 8-16 hours
- 1-2 days
- 2-4 days
- 1 week
- 2+ weeks

- What is most important to you?

- To wash on a particular day.
- To wash at a certain time of the day.
- -> None of them are important to me.

- [optional] which days or periods do you prefer to wash clothes?

When it fits, there is a lot of people who wash in the weekends, where people cut in front of the line.

- How satisfied would you be if you and other residents could book a washing machine in advance?

- Very unsatisfied
- Unsatisfied
- Neutral
- Satisfied
- -> Very satisfied

- rank these functionalities according to what you would like to see in an application

1. booking of the washing machine
2. display of whether a washing machine is in use
6. receive notification when my wash is done

4. receive notification when a washing machine is free
5. automatic log in when I start the app
3. automatically connect to the laundry room's local wifi

- **What is good about your current system?**

That i am one of the few who use it. It works as it should. I have nothing against the current system, except for a missing booking feature. I don't mind using 5's.

- **What is bad about your current system**

Lack a booking feature. People do not follow the schedule on paper.

- **Which phone do you use?**

IPhone XR

- **Which version is the operating system?**

15.4

- **Additional comments**

- **UI comments**

Would prefer to see 100 kr instead of 20 tokens.

Would prefer a regular calendar, where you choose a date and then a time.

Would prefer a bright design.

As long as it works the design is not important.

D PRE TREATMENT INTERVIEW

This interview was created using guidelines for creating a post-test questionnaire using the System Useability Scale (SUS) to get immediate feedback on the useability of the system as described by [7]. The interview was likewise translated to danish, given the respondents were danish. The bold subsection were not to be presented to the interviewed person, but is presented here to give a better overview to the interviewer, where they are in the process.

System Useability Scale For each question, the user could give a score ranging from 1 to 5, with 1 being Strongly disagree, 3 being neutral and 5 being Strongly agree.

- I think i would like to use the system frequently
- I found the system unnecessarily complex
- I thought the system was easy to use
- I think i would need the support of a technical person to be able to use this system
- I found the various functions in this system were well integrated
- I thought there were too much inconsistency in the system
- I would imagine that most people would learn to use this system very quickly
- I found the system cumbersome to use.
- I felt very confident in using the system
- I needed to learn a lot of things to be able to use the system

Validation of Laundry Times Questions are asked vaguely, given some of this information will be used to modify green/yellow/red times.

- The usual washing time is late evening/night?
- Which times would you say are most normal for you?
- The usual washing days are in the weekend?
- Which days would you say are the most normal for you?
- How many consecutive hours do you do laundry when you activate a machine.

Experienced Problems These questions will be accompanied with a walk through the whole app. If they answer yes to a question, ask what they experienced, how it affected them and what they had expected instead.

- Have you experienced any problems in login?
- Have you experienced any problems at the home screen?
- Have you experienced any problems at the booking screen?
- Have you experienced any problems at the wash screen?
- Have you experienced any problems when using the app in the laundry room?
- Have you experienced any problems when using the app when not in the laundry room?
- Have you experienced any problems in getting into contact with us, if you needed help?

End the interview with "If you could add or change one thing about the app, what would it be?". This is done to end the interview on a lighter note, and get feedback on expectations on what the most logical next step should be, if development of the system were to continue.

D.1 Results

Pre treatment results presented below where 1 is strongly disagree, 2 is disagree, 3 is neutral, 4 is agree and 5 is strongly agree.

Question	2.th	3.th	4.tv
I think i would like to use the system frequently	4	5	5
I found the system unnecessarily complex	2	2	1
I thought the system was easy to use	4	4	4
I think i would need the support of a technical person to be able to use this system	2	2	1
I found the various functions in this system were well integrated	4	4	4
I thought there were too much inconsistency in the system	2	1	1
I would imagine that most people would learn to use this system very quickly	4	5	4
I found the system cumbersome to use.	1	2	2
I felt very confident in using the system	4	5	5
I needed to learn a lot of things to be able to use the system	2	3	1
The usual washing time is late evening/night?	4	5	4
Which times would you say are most normal for you?	mostly night	Either before middage or late evening/night	Before midday
The usual washing days are in the week-end?	5	5	4
Which days would you say are the most normal for you?	saturday	All days	mondays and tuesdays
How many consecutive hours do you do laundry when you activate a machine.	2.5 hours	5 hours	4 hours

Have you experienced any problems in login?	It did throw me off one time, but logged me automatically in again	Wouldn't work because i was autoconnected to that local wifi (no internet connection)	no
Have you experienced any problems at the home screen?	I experienced a double payment ones	no	Bookings from last month reappear and the UI feels as though it is possible to scroll
Have you experienced any problems at the booking screen?	no	no	no
Have you experienced any problems at the wash screen?	no	I had to help my sister ones, because she couldn't understand how to use the dryer, so i had to do it	Confusing (Why does it feel as though one can scroll when it is not possible?)
Have you experienced any problems when using the app in the laundry room?	no	Automatic connection to the local wifi so it couldnt log in correctly	Same as previous answer
Have you experienced any problems when using the app when not in the laundry room?	no	no	Not really
Have you experienced any problems in getting into contact with us, if you needed help?	absolutely not	no	Haven't needed any help
If you could add or change one thing about the app, what would it be?	Notification when the laundry is finished (not only the booking)	That it is possible to activate ones for all consecutive bookings and that it is possible to activate from the apartment, so it is not necessary to have the mobile to the laundry	Easter eggs, hidden things in the app to unlock

Comments: 4. tv have tried to stress test the app, but found it to still be responsive. 4. tv also mentioned that the black background colour was a good choice. When contacting 2.th why they had not used the system, they said they simply forgot about it since they are not used to use the laundry room, given they have their own washing room, and simply reverted to bad habits.

E POST TREATMENT INTERVIEW

This interview was created using guidelines for creating a post-test questionnaire using the System Usability Scale (SUS) as described by [7]. The interview was likewise translated to Danish, given the respondents were Danish. The subsections would not be presented to the interviewed person, but is presented here to give a better overview to the interviewer, where they are in the process.

System Usability Scale

For each question, the participant could give a score ranging from 1 to 5, with 1 being Strongly disagree, 3 being neutral and 5 being Strongly agree.

- I think I would like to use the system frequently
- I found the system unnecessarily complex
- I thought the system was easy to use
- I think I would need the support of a technical person to be able to use this system
- I found the various functions in this system were well integrated
- I thought there was too much inconsistency in the system
- I would imagine that most people would learn to use this system very quickly
- I found the system cumbersome to use.
- I felt very confident in using the system
- I needed to learn many things to be able to use the system

Green laundry

For each question, the participant could give a score ranging from 1 to 5, with 1 being Strongly disagree, 3 being neutral and 5 being Strongly agree.

- I have tried to actively choose green times
- I check the app before I schedule my laundry
- I feel I have used the laundry more than usual for the last 2 weeks
- I think the colors have helped me to make informed choices
- I have used the app outside strictly scheduling and activating laundry machines
- I have tried to actively avoid red times
- I have made up my mind before checking the app, when I'm doing my laundry
- I feel I have used the laundry less than usual for the last 2 weeks
- I don't think there is enough information so I can make an informed choice
- I have tried to use the app only when necessary

The next couple of questions should reference their latest booking

- At your latest booking, did you choose the time thinking about the color?
- At your latest booking, did you choose the time primarily because it fitted your plans?
- At your latest booking, did you feel the colors influenced how you felt about the choice?
- At your latest booking, did you feel the colors influenced your actual choice?

Comparison with Laundromat

For each question, the user could give a score ranging from 1 to 5, with 1 being Strongly disagree, 3 being neutral and 5 being Strongly agree.

- The app is better than the laundromat
- I have experienced fewer issues with the app than with the laundromat
- Compared to the laundromat, the app feels better to use
- Compared to the laundromat, the app is more convenient
- Compared to the laundromat, the app feels easier to use when activating a machine
- The app gives useful and relevant information compared to what the laundromat could

This interview is about getting their thoughts on how their experience was using the app, how their experience was regarding being presented to green score. It is just as interesting to know why they did not do something as why they did do something)

- (If they deleted a booking), do they remember why they did it?
- (Presenting their last booking) What thoughts did you have regarding the colour of your last booking?
- What are you missing from the system?
- Some areas where the system has surprised you?

End the interview with "In its current state, could you see yourself using it instead of the coin-system?". This is done to evaluate whether future development is warranted, and if the system improves the lives of the tenants compared to their immediate options.

E.1 Results

Post treatment results presented below where 1 is strongly disagree, 2 is disagree, 3 is neutral, 4 is agree and 5 is strongly agree.

Question	2.th	3.th	4.tv
I think i would like to use the system frequently	4	4	5
I found the system unnecessarily complex	2	2	1
I thought the system was easy to use	4	5	5
I think i would need the support of a technical person to be able to use this system	2	4	1
I found the various functions in this system were well integrated	4	4	4
I thought there were too much inconsistency in the system	2	1	1
I would imagine that most people would learn to use this system very quickly	4	4	5
I found the system cumbersome to use.	1	1	1
I felt very confident in using the system	5	4	5
I needed to learn a lot of things to be able to use the system	2	3	1
I have tried to actively choose green times	2	1	1
I check the app before I schedule my laundry	1	4	1
I feel I have used the laundry more than usual for the last 2 weeks	3	1	2
I think the colors have helped me to make informed choices	3	1	5
I have used the app outside strictly scheduling and activating laundry machines	4	1	1
I have tried to actively avoid red times	2	1	1
I have made up my mind before checking the app, when I'm doing my laundry	5	5	5
I feel I have used the laundry less than usual for the last 2 weeks	2	1	1
I don't think there is enough information so I can make an informed choice	4	5	1
I have tried to use the app only when necessary	1	5	5
At your latest booking, did you choose the time thinking about the color?	4	4	1
At your latest booking, did you choose the time primarily because it fitted your plans?	5	5	5
At your latest booking, did you feel the colors influenced how you felt about the choice?	2	1	1
At your latest booking, did you feel the colors influenced your actual choice?	1	1	1
The app is better than the laundromat	4	3	5
I have experienced fewer issues with the app than with the laundromat	3	2	5
Compared to the laundromat, the app feels better to use	4	4	5
Compared to the laundromat, the app is more convenient	4	4	5
Compared to the laundromat, the app feels easier to use when activating a machine	3	1	5
The app gives useful and relevant information compared to what the laundromat could	4	4	3

Results for the open questions are presented below.

Question	2.th	3.th	4.tv
(If they deleted a booking) do they remember why they did it?	Was curious and wanted to see how it worked	Booked 5 hours but needed only 2.5	They didn't
	Followed the instructions of the guide	-	-
	It was nice following the guide, to check if one was doing things right	-	-
(Presenting their last booking) What thoughts did you have regarding the colour of your last booking?	It was the best possible day, but if it costed more it might have changed	You got to wash when you got to wash	I would like to believe i'm environmental, but i'm not
	I might change for 5 kr (1 dollar ~7 kr), but 2 kr is too little	I know it sounds bad, but I do not really care about the climate, since it does not have a direct impact on me	Its purely practical
	Could have been nice hitting a green time, but it didnt match this time	Might be more interesting if their were an economic gain	-
	Seems to remember it was "red with red" the whole day	-	-
What are you missing from the system?	Would be nice knowing when a wash is done	I need the old paper so i know who washed before me, in case they haven't taken their laundry	Countdown to when the wash is done
	-	Would be nice if one could book 30 minutes at a time, instead of 2.5 hours	I still need easter eggs and gameification in the system
	-	It is hard to make it as intuitive, as putting a 5 kr into a machine	I would be 100% environmental, if i could save a polar bear
Some areas where the system has surprised you?	Didn't have any expectations, but it did what it should	I am a huge fan of the booking system	It worked everytime, so did what it had to do
	-	Initially thought "the 5'er must not go" but has been convinced its not so bad	-
In its current state, could you see yourself using it instead of the coin-system?	Yes, I am always lacking coins	Neutral, since it wouldn't make a major difference	Yes

F.1 Coloring

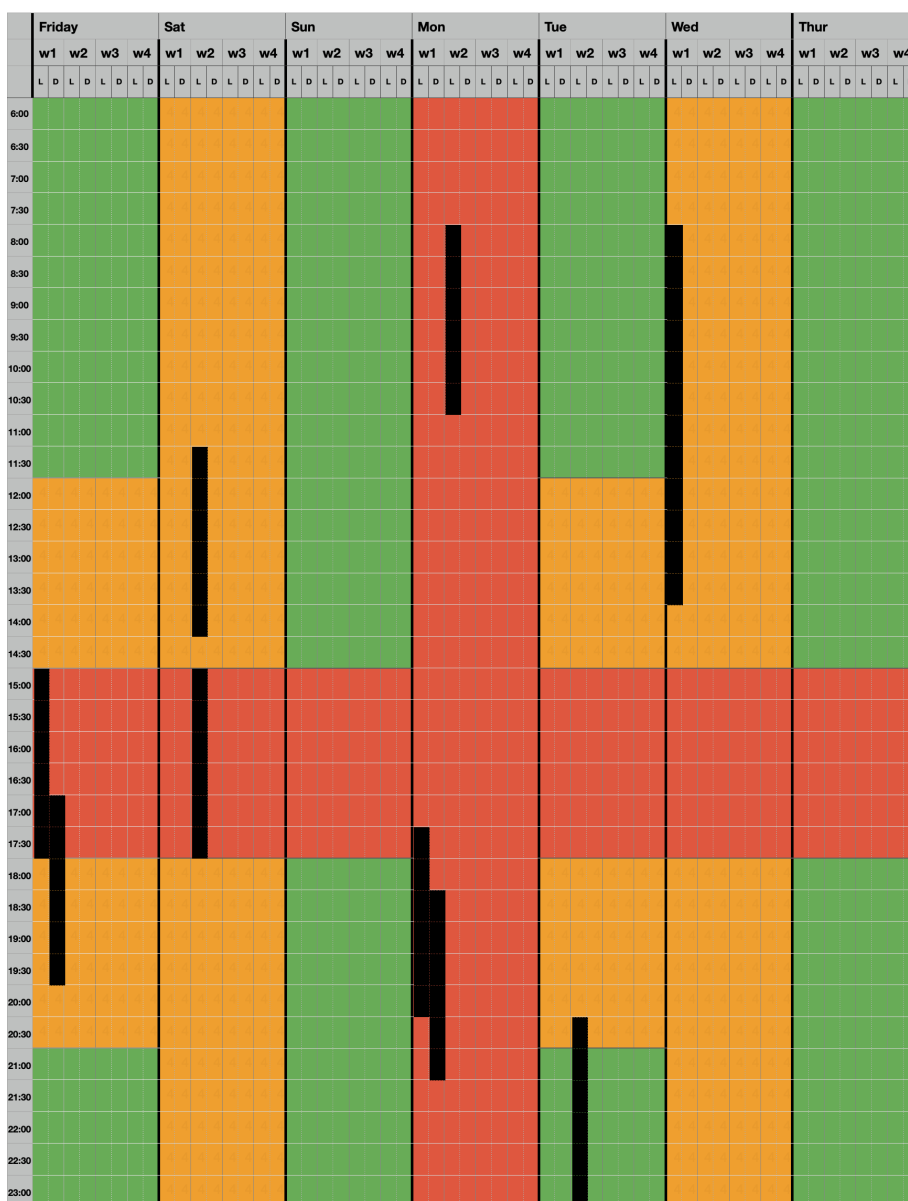


Fig. 6. A schema showing coloring of time slots and registered bookings (black bars) during the two week baseline

F.2 Baseline and Treatment

Week	weekday	from	service	status	booked in advance	time from book to delete	time from book to unlock	time from laundrytime to unlock	account
BASELINE									
1	Friday	22/04/2022 13.00	wash	(deleted)	56m 57s	5s			2. TH
1	Friday	22/04/2022 13.00	wash	(activated)	56m 14s		1h 14m 38s	18m 24s	2. TH
1	Friday	22/04/2022 15.00	Dryer	(activated)	11m 21s		12m 39s	1m 18s	2. TH
1	Monday	25/04/2022 15.30	wash	(activated)	-3m 55s		2m 5s	6m	4. TV
1	Monday	25/04/2022 16.30	Dryer	(activated)	-4m 11s		17s	4m 28s	4. TV
1	Wednesday	27/04/2022 06.00	wash	(skipped)	12h 20m 35s				3. TV
1	Wednesday	27/04/2022 09.00	wash	(skipped)	15h 19m 15s				3. TV
2	Saturday	30/04/2022 09.30	wash	(deleted)	23m 29s	11m 1s			3. TH
2	Saturday	30/04/2022 09.30	wash	(activated)	11m 21s		14m 30s	3m 9s	3. TH
2	Saturday	30/04/2022 13.00	wash	(deleted)	-16m 13s	11s			3. TH
2	Saturday	30/04/2022 13.00	Dryer	(deleted)	42m 9s	5m 52s			3. TH
2	Saturday	30/04/2022 13.00	wash	(activated)	34m 58s		39m 53s	4m 55s	3. TH
2	Monday	02/05/2022 06.00	wash	(activated)	11h 15m 11s		11h 16m 15s	1m 4s	4. TV
2	Tuesday	03/05/2022 18.30	wash	(activated)	-11m 5s		5m 2s	16m 7s	4. TV
TREATMENT									
3	Monday	09/05/2022 16.00	wash	(activated)	1m 57s		5m 21s	3m 24s	2. TH
3	Monday	09/05/2022 17.00	Dryer	(activated)	-35m 9s		2m	37m 9s	3. TH
3	Monday	09/05/2022 17.30	Dryer	(deleted)	20m 39s	24m 38s			2. TV
3	Tuesday	10/05/2022 10.30	wash	(activated)	5m 25s		7m 16s	1m 51s	4. TV
3	Tuesday	10/05/2022 14.00	wash	(skipped)	1h 56m 40s				3. TV
3	Thursday	12/05/2022 13.00	wash	(activated)	19m 4s		23m 34s	4m 30s	3. TH
4	Tuesday	17/05/2022 13.00	wash	(activated)	9m 25s		10m 11s	46s	3. TH
4	Wednesday	18/05/2022 06.30	wash	(activated)	56s		2m 21s	1m 25s	4. TV
4	Wednesday	18/05/2022 08.30	Dryer	(activated)	-2m 38s		50s	3m 28s	4. TV
4	Thursday	19/05/2022 16.30	Dryer	(activated)	2h 3m 38s		2h 40m 47s	37m 9s	3. TH

Fig. 7. This table shows all the gathered data split into the Baseline period and the Treatment period. The bookings are listed by date and are in UTC time, 2 hours must be added to get the corresponding Danish time. The table shows how long time in advance a booking was created, the duration from the booking of a laundry time till the user activates the booked machine and how late the users activate their booked laundry time. The deleted bookings are marked in red and the bookings that were not activated from the app are highlighted in yellow

F.3 Data sorted by account

All the gathered data sorted on account is shown in table 8

Week	weekday	from	status	service	booked in advance	time from book to delete	time from book to unlock	time from laundrytime to unlock	account
1	Friday	22/04/2022 13.00	(deleted)	wash	56m 57s	5s			2. TH
1	Friday	22/04/2022 13.00	(activated)	wash	56m 14s		1h 14m 38s	18m 24s	2. TH
1	Friday	22/04/2022 15.00	(activated)	Dryer	11m 21s		12m 39s	1m 18s	2. TH
3	Monday	09/05/2022 16.00	(activated)	wash	1m 57s		5m 21s	3m 24s	2. TH
3	Monday	09/05/2022 17.30	(deleted)	Dryer	20m 39s	24m 38s			2. TV
2	Saturday	30/04/2022 09.30	(deleted)	wash	23m 29s	11m 1s			3. TH
2	Saturday	30/04/2022 09.30	(activated)	wash	11m 21s		14m 30s	3m 9s	3. TH
2	Saturday	30/04/2022 13.00	(deleted)	wash	-16m 13s	11s			3. TH
2	Saturday	30/04/2022 13.00	(deleted)	Dryer	42m 9s	5m 52s			3. TH
2	Saturday	30/04/2022 13.00	(activated)	wash	34m 58s		39m 53s	4m 55s	3. TH
3	Monday	09/05/2022 17.00	(activated)	Dryer	-35m 9s		2m	37m 9s	3. TH
3	Thursday	12/05/2022 13.00	(activated)	wash	19m 4s		23m 34s	4m 30s	3. TH
4	Tuesday	17/05/2022 13.00	(activated)	wash	9m 25s		10m 11s	46s	3. TH
4	Thursday	19/05/2022 16.30	(activated)	Dryer	2h 3m 38s		2h 40m 47s	37m 9s	3. TH
1	Wednesday	27/04/2022 06.00	(skipped)	wash	12h 20m 35s				3. TV
1	Wednesday	27/04/2022 09.00	(skipped)	wash	15h 19m 15s				3. TV
3	Tuesday	10/05/2022 14.00	(skipped)	wash	1h 56m 40s				3. TV
1	Monday	25/04/2022 15.30	(activated)	wash	-3m 55s		2m 5s	6m	4. TV
1	Monday	25/04/2022 16.30	(activated)	Dryer	-4m 11s		17s	4m 28s	4. TV
2	Monday	02/05/2022 06.00	(activated)	wash	11h 15m 11s		11h 16m 15s	1m 4s	4. TV
2	Tuesday	03/05/2022 18.30	(activated)	wash	-11m 5s		5m 2s	16m 7s	4. TV
3	Tuesday	10/05/2022 10.30	(activated)	wash	5m 25s		7m 16s	1m 51s	4. TV
4	Wednesday	18/05/2022 06.30	(activated)	wash	56s		2m 21s	1m 25s	4. TV
4	Wednesday	18/05/2022 08.30	(activated)	Dryer	-2m 38s		50s	3m 28s	4. TV

Fig. 8. This table shows all the gathered data sorted on account and are in UTC time, 2 hours must be added to get the corresponding Danish time. The table shows how long time in advance a booking is created, The duration from the booking of a laundry time till the user activates the booked machine and how late the users activate their booked laundry time. The deleted bookings are marked in red and the bookings that were not activated from the app are highlighted in yellow

F.4 Results Diagram

The data gathered from the 4 week experiment is presented on the next page. The baseline columns, week 1 and 2, has a white background. The treatment period - the next 2 weeks after the baseline weeks - displays the colors associated with each time-slot from 06-23. Each participant - 2th, 2tv, 3th, 3tv and 4tv - has a distinct color and their bookings are represented by the vertical blocks associated with their respective distinct color.

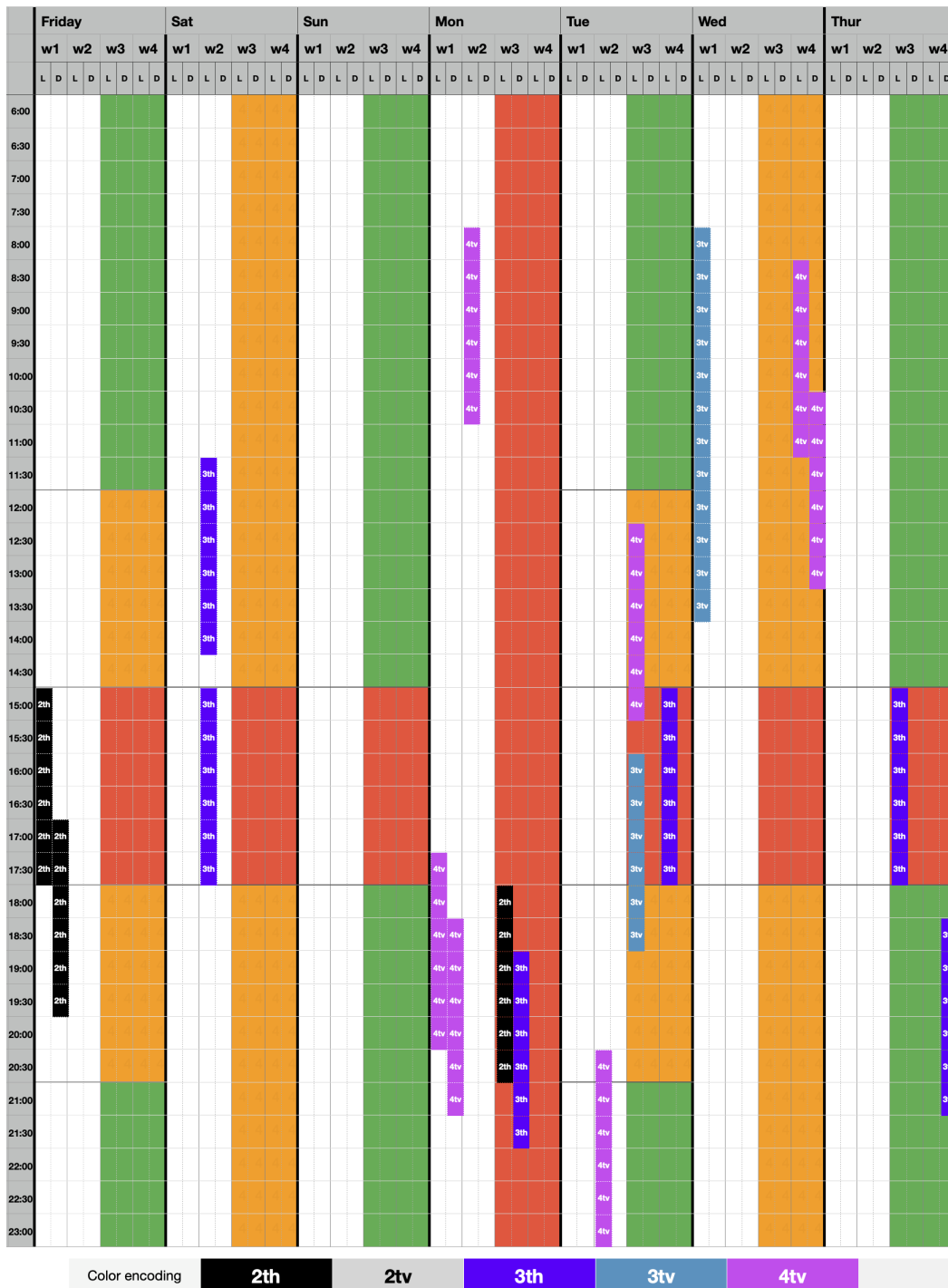


Fig. 9