Shower Routine Creation: Application Design in a User-Centered Process

Teodor Ahlinder Jakob Sjödin

Department of Design Sciences

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Teodor Ahlinder
teodor.ahlinder@me.com

Jakob Sjödin
jakob@sjodin.net

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the Department of Design Science, Faculty of Engineering, Lund University.

Supervisors: Günter Alce, gunter.alce@design.lth.se
Nils Goksör, nils@orbital-systems.com
Mateo Gianolio, mateo@orbital-systems.com

Examiner: Joakim Eriksson, joakim.eriksson@design.lth.se

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Abstract

A *shower routine* is a sequence of instructions that can be executed by a smart shower. This report explores how interfaces for creating shower routines can be designed. It further investigates the features that users prioritize in such an interface and how shower routines can enhance the shower experience.

Based on Orbital Systems' app My Water, prototypes for various design solutions were created in an iterative process with a strong focus on user testing. Initially, literature studies and user tests of My Water were conducted to identify areas for improvement. Subsequently, three iterations of prototype development were carried out. In the first iteration, five prototypes were designed and tested through lo-fi prototyping. In the second iteration, two additional prototypes were designed and tested based on the earlier ones. In the third iteration, the best-performing prototype was further developed using hi-fi prototyping, and the prototype was then tested against the existing app.

The best design turned out to be a block-based interface reminiscent of existing calendar apps, and the hi-fi prototype of the interface performed significantly better than the existing app during user tests. In terms of functionality, the work shows that users have a certain interest in accessing pre-made standard routines, controlling the type of water stream, and combined control of music and lighting. The time-specific nature of shower routines was found to be a significant advantage, leading to water conservation and eliminating the risk of a shower session exceeding the planned duration. Furthermore, shower routines can make the shower more accessible for users who have difficulty using regular shower controls.

Keywords: user-centered design, shower, routine, user testing

Sammanfattning

En *duschrutin* är en sekvens av instruktioner som kan exekveras av en smart dusch. Den här rapporten undersöker hur gränssnitt för skapande av duschrutiner kan designas. Vidare undersöks vilka funktioner användare prioriterar i ett sådant gränssnitt samt hur duschrutiner kan förbättra duschupplevelsen.

Med utgångspunkt i Orbital Systems app My Water designades prototyper för olika designlösningar i en iterativ process med stort fokus på användartester. Först genomfördes litteraturstudier och användartester av My Water för att identifiera förbättringsområden. Därefter genomfördes tre iterationer av prototyputveckling. I den första iterationen designades och testades fem prototyper genom lo-fi prototyping. I den andra iterationen designades och testades ytterligare två prototyper, vilka baserades på tidigare prototyper. I den tredje iterationen vidareutvecklades den bäst presterande prototypen med hi-fi prototyping och prototypen testades sedan mot den befintliga appen.

Den bästa designen var ett blockbaserat gränssnitt som påminner om bland annat existerande kalenderappar. Hi-fiprototypen av gränssnittet presterade avsevärt bättre än den befintliga appen under användartester. Vad gäller funktionalitet visar arbetet på att användare har ett visst intresse av tillgång till färdiggjorda standardrutiner, styrning av stråltyp samt kombinerad styrning av musik och ljus. Att duschrutiner är tidsbestämda visade sig vara en viktig fördel då det både leder till vattensparande och eliminerar risken för att en duschsession tar längre tid än planerat. Vidare kan duschrutiner göra duschen mer tillgänglig för användare som har svårt att använda vanliga duschvred.

Nyckelord: användarcentrerad design, dusch, rutin, användartest

Acknowledgements

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Finally, we would like to thank all the participants in the various tests for having a great attitude and providing us with comments and feedback without which this thesis could never have been completed.

Contents

Chapter 1
Introduction

In this chapter, the project background is covered and the purpose and research questions guiding the project are presented. Moreover, the alignment of the project with the UN sustainability goals is discussed as well as ethical considerations. Finally, previous work relating to the project is explored.

1.1 Background

Orbital Systems is the company behind the *Orbital Shower*, a climate-friendly shower minimizing waste by reusing water. The Orbital Shower can be controlled by the app *My Water*, to which the company is now considering adding the functionality of custom shower routine creation [16]. By providing users with the ability to pre-program their own shower experience, the company imagines an increase in the overall usability of the app combined with a more enjoyable experience for the users.

Orbital Systems have added a rudimentary design for custom shower routine creation in My Water. Users are able to create their own shower routines by sequencing commands for the Orbital Shower to follow. These commands include turning the water jets on and off, fine tuning water flow, and regulating water temperature. As the custom shower routine functionality was developed within a short time span, only core features of the routine creation were implemented and there was little opportunity for user experience considerations.

The novelty of the Orbital Shower coupled with that of controlling any shower with an app would put most users in an unfamiliar environment. Therefore, one could argue for the vitality of a smooth and intuitive interface to facilitate use of the app.

1.2 Purpose and Research Questions

The primary purpose of this thesis will be to explore what design choices result in the most enjoyable user experience for the custom shower routine creation of My Water, while also examining what functionality users value the most in the interface. The following research questions are to be answered:

- RQ1: How can the shower experience be improved by custom shower routines?
- RQ2: What design choices make for a quality user experience in regard to custom shower routine creation?
- RQ3: What functionality do users prioritize when creating custom shower routines?

1.3 In Relation to the Sustainable Development Goals

The *Sustainable Development Goals* are a UN-created set of goals centered around global sustainability. This project involves exploration of possibilities for improvement of the My Water app used to control products by Orbital Systems. The central aspect of these products is sustainable water consumption, and the products are used by both businesses and private individuals. Hence, the project aligns well with goal 9: "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation," goal 11: "Make cities and human settlements inclusive, safe, resilient and sustainable," and goal 12: "Ensure sustainable consumption and production patterns," see Figure 1.1 through Figure 1.4 [19].

Figure 1.1: Goal 6: "Ensure access to water and sanitation for all."

Figure 1.2: Goal 9: "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation."

Figure 1.3: Goal 11: "Make cities and human settlements inclusive, safe, resilient and sustainable."

Figure 1.4: Goal 12: "Ensure sustainable consumption and production patterns."

1.4 Ethics

The ethical considerations in this project generally concern water consumption. In theory, a significant advantage of shower routines is the entailed limit of the duration of showers; once the shower routine has been fully executed, the water will be turned off. For people with a propensity for long, leisurely showers, shower routines could constitute an opportunity to conserve water. On the other hand, the shower routine functionality could conceivably be designed in such a way that it encourages longer showers, perhaps by simply making showering more enjoyable.

1.5 Related Work

Throughout the project, previous work in adjacent areas served as inspiration.

1.5.1 Existing Designs with a Similar Purpose

While no designs with the explicit purpose of shower routine creation could be found, a few systems designed to perform similar tasks were encountered during literature studies.

Workout Templates in Strong

Strong is a dual-purpose gym app designed for tracking workout progress and planning strength training. Training is mainly planned through the creation of workout templates. When creating a template, the main view provides an overview of the routine being created. It lets

the user give their template a name, write a description, and add exercises that are to be performed. Exercises are selected from a vertical list with a search bar at the top, and are stacked vertically in the routine overview once added. For added exercises, the user can adjust the weight to be used and the number of repetitions to be performed. The properties of an exercise, e.g. its weight and repetitions, are displayed in columns clearly grouped with the exercise title, as can be seen in Figure 1.5 [18].

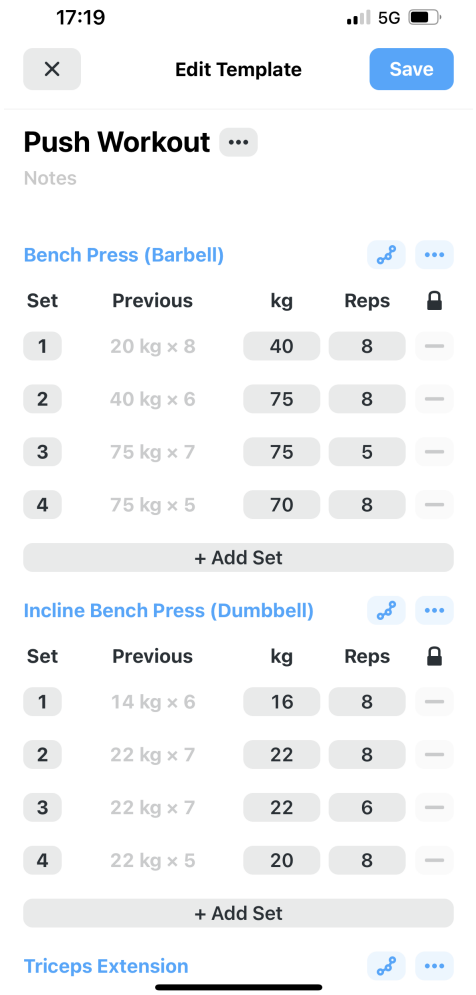

Figure 1.5: Workout template in Strong.

Automation Clips in Digital Audio Workstations

Digital Audio Workstations, commonly abbreviated as DAWs, are software applications used in digital music production. Some of the most prominent DAWs, such as Logic Pro and FL Studio, feature *automation clips*. Automation clips instruct the software how the quantity of e.g. sound volume should vary over time. Figure 1.6 shows an automation clip controlling the volume of piano chords in FL Studio. An automation clip typically consists of a graph, with the area under the graph representing the quantity of the property being controlled as it varies over time. The graph can be fine-tuned by the addition and manipulation of nodes [12].

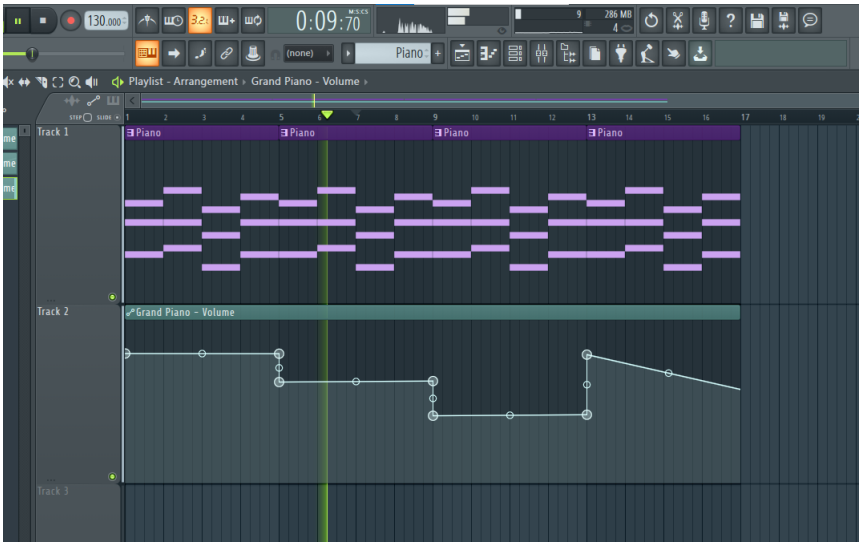

Figure 1.6: Manipulation of volume of piano chords (purple) by means of an automation clip (teal) in FL Studio.

Google Calendar

There are a multitude of calendar apps for smartphones, one of the most prominent being *Google Calendar*. In Google Calendar, the user can create a schedule for their day by creating *events*. The user can customize the title, the color, the times of day when the event begins and ends, and a number of other features of the event. Upon completion, the event is added to a timeline based on when it begins and ends, as seen in Figure 1.7. The user can also add *tasks* that are to be completed at a specific time. Items placed on the timeline can be moved around by pressing and dragging [10].

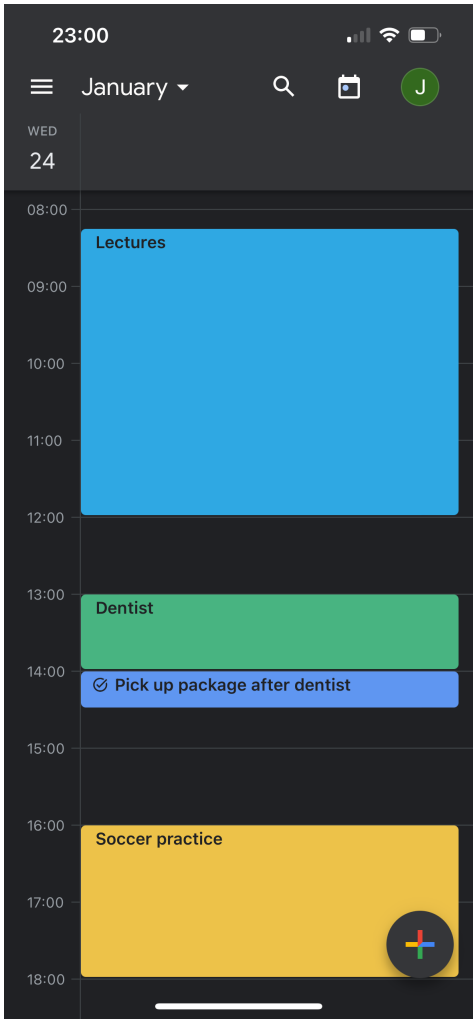

Figure 1.7: Schedule for a day in Google Calendar.

Chapter 2
Theory

In this chapter, the theory on which the project relies is explained. It consists of two parts, the details of the My Water app serving as the base design in the project, and the design principles guiding development.

2.1 The My Water App

My Water is an app developed by Orbital Systems. By pairing the app with their Orbital Shower, users can for example access their shower history and track how much water they have conserved by using the Orbital Shower instead of a regular shower [1].

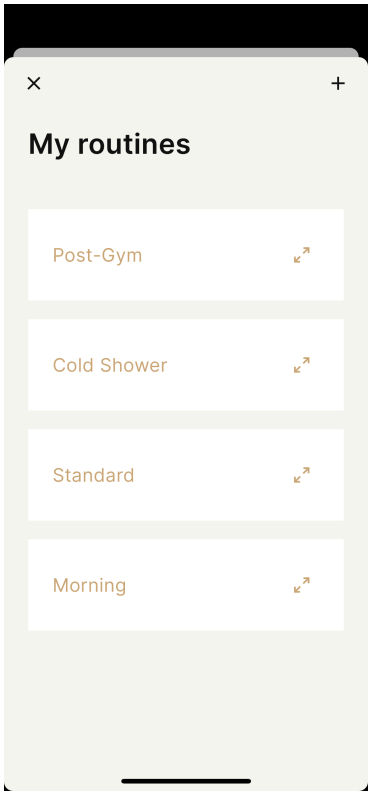

Figure 2.1: Overview of routines previously created by the user.

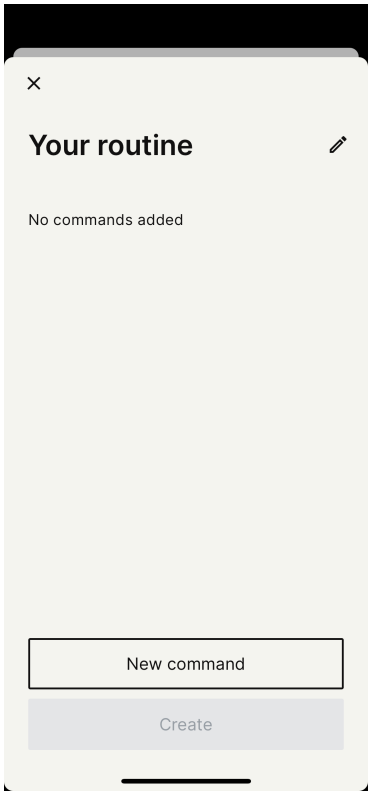

Figure 2.2: Routine creation overview before any commands have been added.

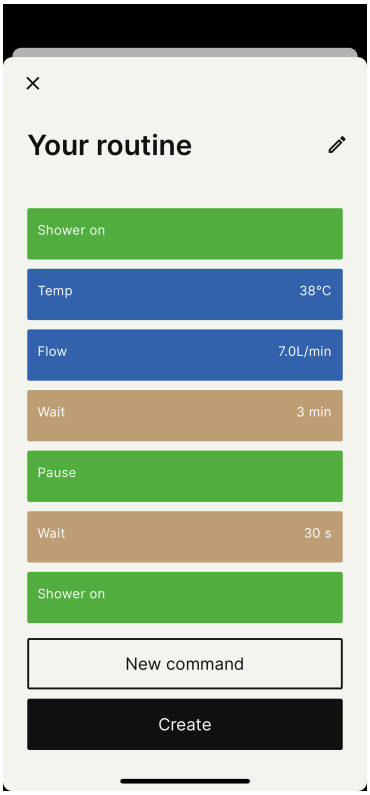

Figure 2.3: Routine creation overview while commands are being added.

The nascent shower routine functionality is currently only available in the development version of the app. In this version, the main view provides an overview of the routines the user has created, as in Figure 2.1. The bars representing the routines can be pressed to edit the routines.

In the top-right corner, there is a small plus which can be pressed to start creation of a new routine. This takes the user to a mainly blank view headlined "Your routine", as displayed in Figure 2.2. The "New command" button at the bottom of the screen can be pressed to add commands to the routine. The user is then taken to a view with a list of commands, from which the user can select a command by pressing it, and then adding it by pressing the "Add" button to the bottom-right of the view.

There are six commands to choose from: "Shower on," "Pause," "End session," "Wait," "Temp," and "Flow." The "Shower on" command means turning the water on, "Pause" means turning the water off, "End session" means concluding the routine, "Wait" means maintaining the current settings for the specified period of time, "Temp" means setting the temperature to the specified number of degrees, and "Flow" means setting the water flow to the specified liters/minute. Upon selection of either of the three commands mentioned last, an appropriate dial appears below the command list, as seen in Figures 2.4-2.6.

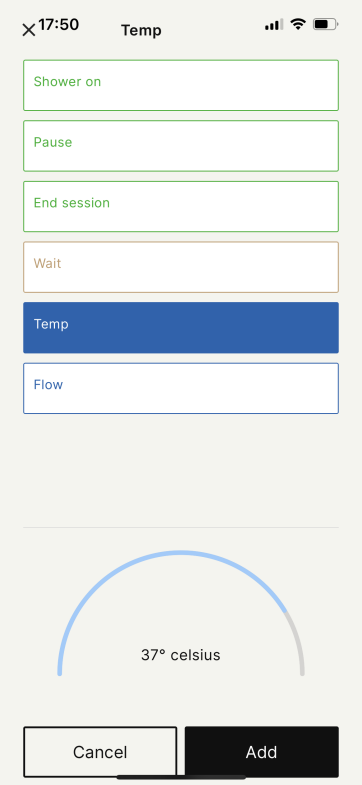

Figure 2.4: Addition of a Temp command in My Water.

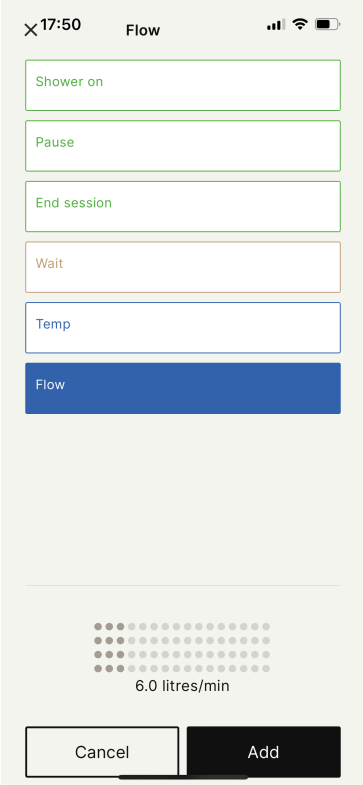

Figure 2.5: Addition of a Flow command in My Water.

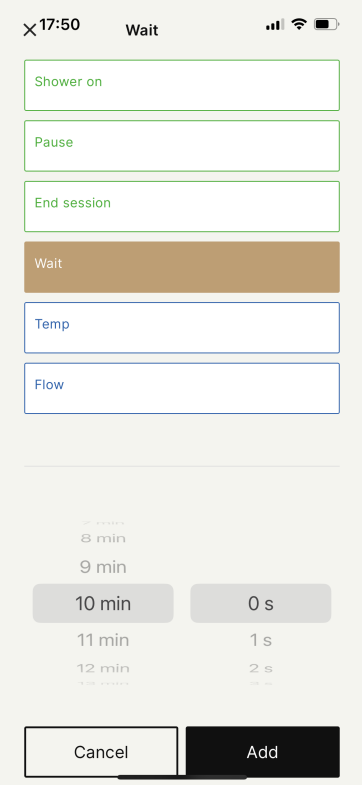

Figure 2.6: Addition of a Wait command in My Water.

Added commands are stacked vertically in the routine creation overview, as displayed in Figure 2.3. The actual effects of the commands vary based on implicit, position-based connections to other commands. "Shower on" will do nothing if the water has already been turned on by a prior "Shower on" command, and "Pause" will do nothing if the water is already off. A "Wait" command dictates the effect of the commands above it insofar as it instructs the shower to keep the current settings for a certain amount of time. "Temp" and "Flow" commands need a "Shower on" command to have effect, as neither of the previous turns the water on.

Created routines can be edited by pressing them. Editing an existing routine functions much in the same way as creating a new routine.

2.2 User-Centered Design Terminology

In user-centered design, a number of principles have been established to guide the design process [17].

2.2.1 Brainstorming

Brainstorming is a powerful technique for any design process. By exploring a well defined problem from many approaching angles, a design team can invent a diverse collection of

potential solutions. Keeping an outside-of-the-box thinking, the team is allowed and encouraged to find new pathways to success, instead of following conventional ones. Indeed, teams using brainstorming to propel their early design process are encouraged to prioritize quantity over quality.

An integral part of brainstorming is to keep an open mind. Judging novel ideas too early can block of new pathways before any exploration of them has begun. Instead, ideas can be built on other ideas, further propelling the creative process and discovering new possibilities [7].

2.2.2 Personas

A *persona* is a detailed description of a typical user of a system based on a combination of what are believed to be actual users. A persona contains information about the user's profession, hobbies, attitudes, and behaviors, as well as a set of the user's goals vis-a-vis the system being developed [6] [4].

2.2.3 Prototyping

During a design process, design teams can capture design concepts in *prototypes*, allowing them to try out these concepts with users before any finalized product is released. Such prototypes allow the teams to iterate their ideas in a more effective manner, in order to find the solutions best suited for any task or problem. Various degrees of fidelity, from pen-and-paper prototypes (also known as lo-fi prototypes), to complete digital systems (apps, also known as hi-fi prototypes), can be created - based on the design concepts to be tested, and the users interaction feedback and preferences [8].

2.2.4 Conceptual Model

A *conceptional model* is a general description of a system or product. It comprises what a user can do with a product and what concepts they need to grasp in order to be able to interact with it [17] [15] [5].

Mental Model

In order to create any successful design, a designer needs to be aware of the *mental model* of the intended user. A mental model describes how a person understands and expect the world to work and function. A common mental model of mobile apps is that they can be interacted with by using ones fingers. If there is a "X" symbol somewhere in an upper corner, a user might expect an app to close if that X is pressed. Mental models might also have a connection to real-world concepts, such as a digital "shopping cart" on a webshop page. The user browsing the page and its wares will have an understanding of filling their digital shopping cart with items, if they have done so in a real-world store, with tangible items and carts (which most people have) [5] [13].

As such, a designer needs to examine and try to understand the mental models of the users intended to interact with any design. Failing in doing so might result in a seemingly perfect design, that no-one knows how to use.

2.2.5 Semi-Structured Interview

A *semi-structured interview* is a type of interview comprised of a mix of open and closed questions. A general script is employed to ensure that the key aspects of the study are covered with each person being interviewed. Moreover, follow-up questions are asked in between scripted questions until the responses no longer contain any pertinent new information [9] [2] [17].

2.2.6 Think Aloud

When testing a product with a user, it can be hard for the test evaluator to understand the experience experienced by the user. Users bring their own previous experiences, prejudices and expectations into the test environment - aspects that the evaluator cannot hope to understand in the same way as the tester. In order to ensure that the evaluator gains as much insight as possible into the thoughts and experiences of the user, they can ask the latter to "Think aloud" [14] [11] while they go through the various steps of the testing process. The user is prompted to verbalise their thoughts, ranging from what they perceive, what actions they think are possible, to what they would like to do, what they think they should do, and how they feel about the experience as a whole, and more. Evaluators might find that some users can have a hard time doing this, particularly if they are not used to speaking their mind.

2.2.7 Affinity Diagram

An *affinity diagram* is a way of organizing data gathered during e.g. forms or interviews. Individual ideas are written on notes, which are then clustered with other notes that are considered similar in some respect. As more notes are added, groups begin to form, revealing common themes in the data [17].

2.2.8 System Usability Scale

The *System Usability Scale*, often abbreviated as *SUS*, is an expedient tool for gauging the usability of a system or product. It+is a questionnaire comprised of 10 standardized statements, such as "I think that I would use this system frequently." and "I thought the system was easy to use." The respondent answers each statement with a number ranging from one to five depending on the degree to which they agree with the statement, with 1 being "Strongly disagree" and 5 being "Strongly agree." [3]

2.2.9 Design Nomenclature According to Norman

Donald Norman is one of the great names, and indeed pioneers, of interaction design. In 1988, he published his book "The design of everyday things", which was later revised, expanded and republished in 2013 [15]. In it, he outlines various important design-aspects. In this thesis, three of them will be referenced with some frequency:

Affordances

According to Norman, the term affordance is "a relationship between the properties of an object and the capabilities of the agent that determines just how the object could possibly be used". The agent in this instance refers to a person (or animal, machine or robot) interacting with the object. In short, the term dictates the possible actions that an agent can take in any interactive interface that produces some sort of result [15].

Signifiers

For users to discover what affordances exists in a design, a powerful tool are signifiers. A signifier is a property of an interactive interface that allows the user to find affordances. Where an affordance describes what actions are available, "signifiers communicate where an action should take place", Norman states. Examples of signifiers appliable to app design could include signs, buttons, icons, shapes or colors [15].

Constraints

Another powerful tool to let users discover affordances are constraints. As opposed to signifiers, constraints limit the user to help them think of the "right" things during discovery. According to Norman, "constraints are powerful clues, limiting the set of possible actions". By not allowing certain actions, users are rail-roaded into trying actions familiar to them. A smart designer can use their understanding of the users experiences to allow their designs to become intuitive and easy-to-use for the intended user [15].

Chapter 3
The Design Process

This chapter covers the process of designing the shower routine creation interface. This process consisted of a pre-design analysis and three subsequent iterations of design work. Each iteration consisted of design and user tests of prototypes. The first and second iterations involved lo-fi prototyping, while the third involved hi-fi prototyping.

Throughout this thesis, figures 3.1, 3.7, 3.15, 3.22, 3.27 will help the reader track their progress through the design process.

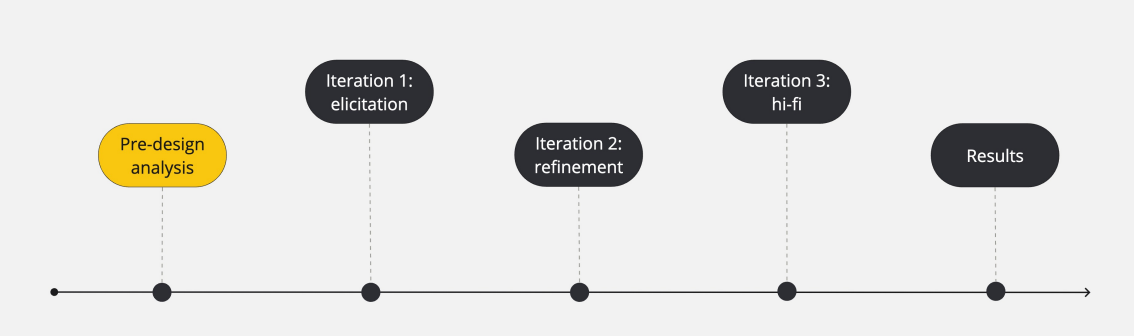

Figure 3.1: Showing what part of the design process is presented in this section.

3.1 Pre-Design Analysis

In order to better understand the users, their expectations and experiences with showering, and the company's previous efforts and work with regard to the "My Water" application and the shower routine functionality in particular, several interviews and tests were held at an early stage of the project. This section outlines these interviews and tests, how they were conducted, and the results they yielded.

3.1.1 Interviews with Orbital Systems Staff

To better understand the motivation and development behind the current shower routine functionality of the "My Water" app, interviews with key staff at Orbital Systems were held. These key persons included the visionary behind the shower routine functionality, the software engineer who programmed the current version, and two of the company's user interface (UX) designers.

Interviews where held in the semi-structured format presented in section 2.2.5, where some open-ended questions led the interviewees to freely elaborate on the following subjects:

- The intended target groups of the shower routine functionality.
- The focus of the company with regards to the users.
- How the company defines their product value.
- How to improve the shower experience for the user.
- The vision and reasoning behind the creation of the shower routine functionality.
- Future expansions and development of the shower routine functionality.
- The involvement of users and user testing in the company history.

From these interviews, it became clear that the shower routine functionality had not yet been tested with users. It was in a very early development stage, solely based on the views

and imagination of the original visionary and the software engineer who programmed the beta version for the app "My Water". Since including users in development is paramount to achieving a well-designed product, it was decided that testing the current interface of the shower routine creation process should be among the first steps taken. The target groups were described by the staff as four distinct groups, namely:

- "Techies" - people with a mid-to-high level of understanding technology, who thrive in digitalizing their lifes.
- "Environmentalists" - people who care greatly about the climate and environment, and who wish to reduce their impact on our planet.
- "Healthies" - people who care for their health and wish to have some, or total control over aspects of their life that affect their health.
- "Tesla owners" - people who find technological advances exciting and have money to spend on acquiring expensive items.

Interviews also revealed that the expandability of the shower functionality is great, and something the company is already looking into. The control of water flow and temperature is fundamental in the shower concept, but the ability to integrate light control, sound control (from playing music, to informing about traffic or weather), and perhaps even assisting in drying off after a shower are all novel ideas that users might not expect. Indeed, since showering is by no means a novel idea, users might have a hard time imagining these new abilities (being stuck in a very firm belief of what a showering experience entails).

Based on these interviews, brainstorming sessions (see section 2.2.1) were held, and a mental model (see section 2.2.4) of the requirements of the interface was developed, as follows:

- One should be able to program a shower routine.
- One should be able to see their programming while they are setting it up.
- One should be able to adjust water flow, temperature, and spray intensity. Additional features such as music, lighting, and reading of information (calendar, weather, traffic) are desirable.
- One should be able to create/delete multiple routines.
- One should be able to name their routines and change names.

3.1.2 Preliminary User Tests of Shower Routine Creation in My Water

Results and Analysis

The preliminary tests where summarized using an Affinity Diagram (see section 2.2.7) which revealed the following:

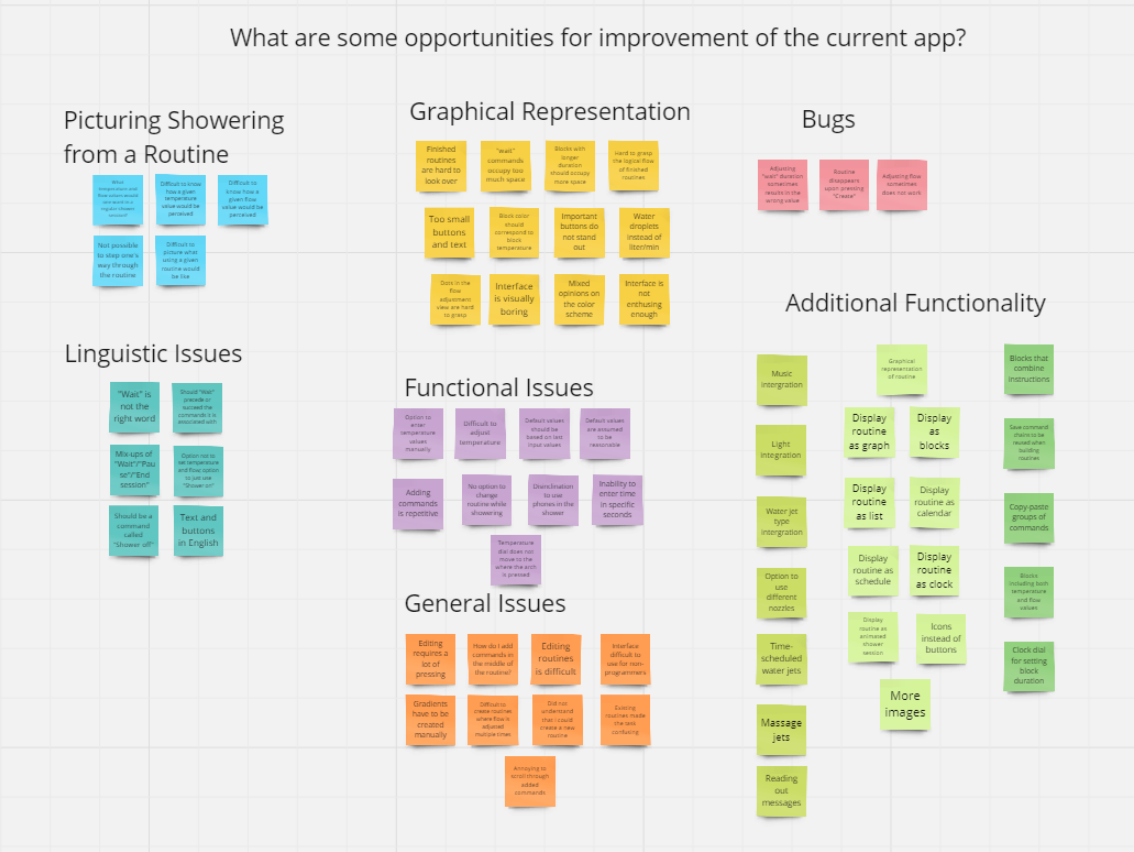

Figure 3.2: Affinity diagram for potential for improvement of My Water.

- Users expressed strongly that they wanted a more graphic interface for creating, editing and showing routines. Many users felt that the experience was boring, and that commands presented in the interface were confusing, with some saying that it felt like the current design was "designed by programmers, for programmers to use".
- Users expressed strongly that they were not able to imagine how their created shower routine would be experienced in the shower. This, many claimed, was largely due to the fact that they had no conception of how the water flow and temperature values were in their current showers. It felt like "stabbing in the dark" to try to set values in the interface, and all users expressed that they would probably have to test their routine and edit it afterwards. Some users strongly expressed that they probably would tire of the whole process if they couldn't get good results after a second or third try.
- Users expressed that they had great trouble in controlling the temperature and water flow dials in the app.
- Users expressed that it was difficult to edit a routine, and several users where confused about there already being an example routine in the interface on startup.
- Users expressed that they felt it took to many actions to reach their goal.
- Observations during the tests indicated that many users had a hard time understanding

the "Shower on", "Pause", "End session" and "Wait" commands. These commands, users expressed, were not actions they understood that they needed to take in order to take a shower.

- All users expressed hesitation regarding bringing their cell phones into the shower.

During tests, many novel and interesting ideas were expressed by testers. These, in combination with the criticisms listed above, were used to create the affinity diagram in Figure 3.2 for areas of improvement.

3.1.3 Personas

In order to better understand the users of the intended target groups, four personas were written, as follows:

- **Healthy Anna**, shown in Figure 3.3, experiences that she is unfocused in the mornings at her job. She struggles to get started, and her productivity is low during the mornings. She also finds it difficult to sleep at night, acknowledging that this contributes to her difficulties. Structuring her mornings is a challenge for her, and it often feels like a struggle to get through them. Anna usually showers every day, but always in different ways, and she finds it difficult to spend an appropriate amount of time in the shower. *Anna is assisted by our product, as she can schedule her shower times more controlled and utilize routines to unwind in the evening and get started in the morning.* Frustrations:
  - Tends to shower for too long
  - Never has a plan for showering

Figure 3.3: Healthy Anna.

- **Climate Friendly Karim**, shown in Figure 3.4, has become increasingly worried about the direction the world is heading. Every day, he hears about the climate crisis and has become particularly interested in understanding the world's water consumption. He believes that by conserving water, one can help avert the crisis. Therefore, Karim wants to start monitoring his own water consumption at home. He invests a lot of energy in contemplating his carbon footprint. *Karim is aided by our product, as it allows him to have greater control over how much water is used each time he showers.* Frustrations:
  - Feels that too much water is being used during showers.
  - Feels that he has too little control over his impact on the climate crisis and is stressed about it.

Figure 3.4: Climate-friendly Karim.

- **Lifestyle-changing Oscar**, shown in Figure 3.5, has just emerged from a deep depression and needs a fresh start in his life. He has chosen to change various aspects of his daily routines and has therefore purchased a new, modern shower. Oscar is unsure of how he wants to alter his shower routines but enjoys experimenting with different options. He wants to be able to try out different routines for a period and then start selecting what suits him best. *Oscar is assisted by our product, as it allows him the opportunity to create different routines for various occasions that can be easily renamed and edited.* Frustrations:
  - Perceives showering as routine and uninspiring.
  - Wants to break free from old habits.

Figure 3.5: Lifestyle-changing Oscar.

- **IoT-techie Sara**, shown in Figure 3.6, loves technology. She has always had the latest smartphone, and since the Internet of Things (IoT) became popular, she has started connecting her entire home to the internet. She manages her entire life through her mobile phone and enjoys having full control over the smallest details. When she saw an ad for Orbitals smart and eco-friendly showers, it was a no-brainer for her to get one, as she could then digitize another part of her life! *Sara is assisted by our product, as she can meticulously control her shower experience. The shower is also enhanced with new functionality that allows her to monitor her water consumption and control music, lights, and other aspects during her shower.* Frustrations:
  - Lacks the ability to analyze her shower habits.
  - Does not like using traditional shower controls.

Figure 3.6: IoT-techie Sara.

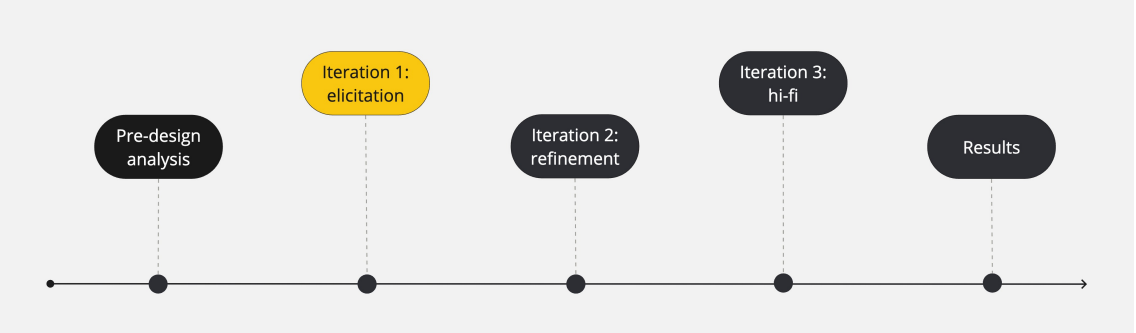

Figure 3.7: Showing what part of the design process is presented in this section.

3.2 Iteration 1: Novel Lo-Fi Prototypes

The primary objective of the first iteration was to explore alternative designs to the My Water app. Five lo-fi prototypes, one of which being a lo-fi representation of the current app, were developed, user-tested, and evaluated. The lo-fi version of the existing app will also be referred to as *My Water*, while the other four prototypes were nicknamed *Iconography*, *CalendarBlocks PinGraph*, and *FreeDraw*.

3.2.1 Design of Prototypes

Except for the lo-fi representation of the current app, each prototype developed in this iteration introduced a fundamental redesign of the shower routine creation interface. The prototypes were developed to each introduce a unique approach to routine creation. By doing so, development could then continue with a narrower focus, with less of a risk of having discarded better alternatives.

The prototypes were fairly limited — they were only equipped with functionality deemed absolutely necessary for shower routine creation. Expressly, no novel ideas such as including lights or sound were included - only functionality to control water flow and temperature was.

In several of these prototypes similar design choices were made regarding the choice of a clock dial as the input of flow, temperature and time values. The preliminary tests outlined in section 3.1.2 showed that all users had a good understanding of the affordances and signifiers (see section 2.2.9) of the clock dial, and that they all tried to operate it in a correct manner (although the dial in those tests did not respond in a satisfying way). Since the preliminary tests also showed that users did *not* understand the dotted increments of the flow value dial, it was decided that *all* dials in the first iteration prototypes should be clock dials. Because of the nature of the flow and temperature values having minimum and maximum values, these clock dials were decided to be presented as "cut". Time dials, on the other hand, were decided to be "uncut", allowing users to continuously advance the dial in either direction (i.e. making full turns), increasing or decreasing the value indefinitely. However, since negative time values in this context makes no sense, it was decided that any attempt at decreasing the time value while it is already at 0 simply would not alter it at all.

In all prototypes where color was used to denote temperature, blue always corresponded to cold, while red always corresponded to hot. This conceptual mapping of temperature to color was deemed to be universally accepted and known throughout society.

Since preliminary user testing showed that users were confused about the many options given to them in the MyWater shower routine creation, care was taken to provide strong constraints to all of the prototypes in this iteration. By limiting the amount of options available to the users, the correct affordances according to their wishes are more likely to be discovered.

During design of these prototypes, the personas outlined in section 2.2.2 provided guidance for how interactions with the interface were assumed to take place.

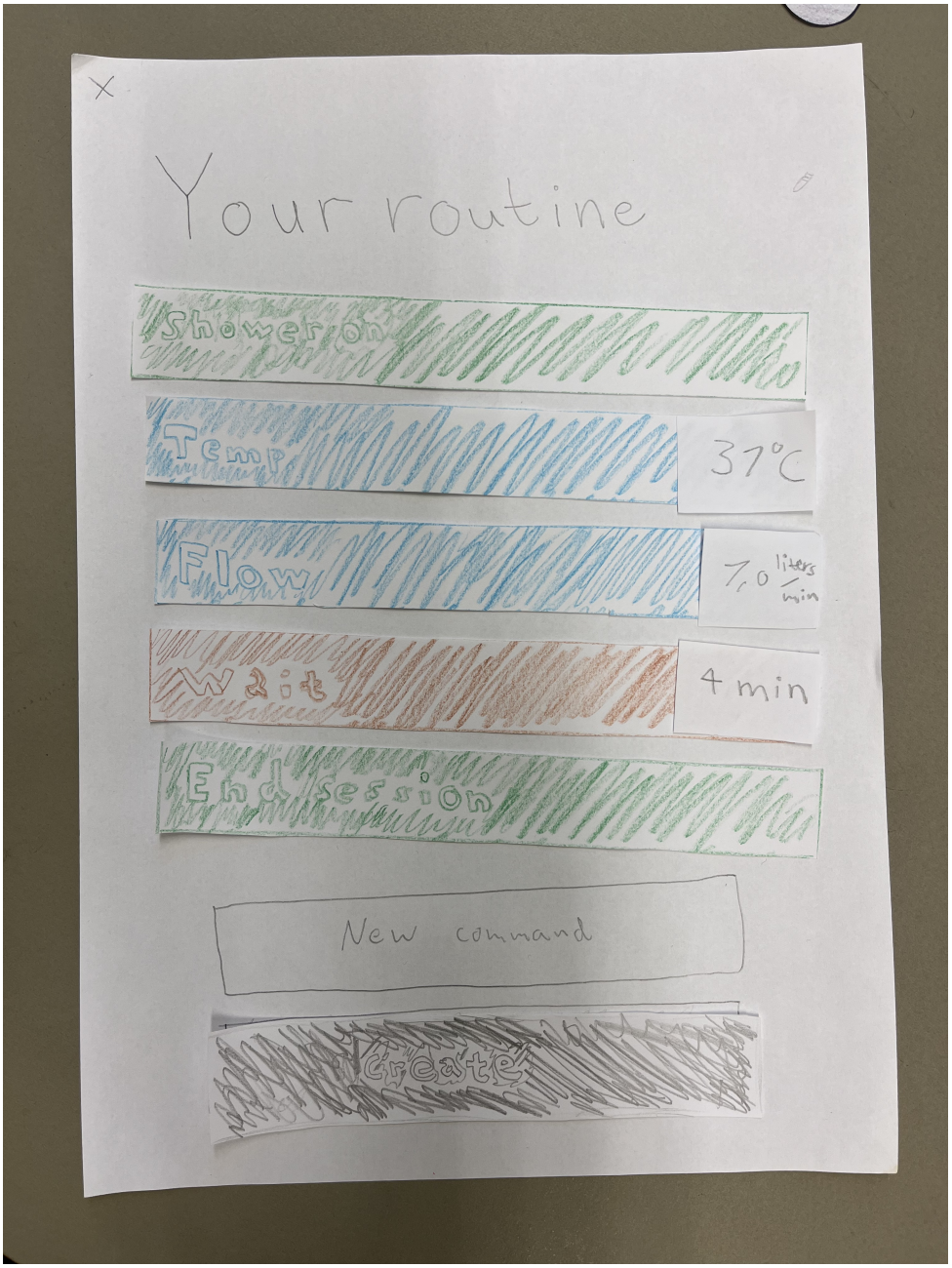

Figure 3.8: Prototype 1A: My Water. Picture taken in the middle of routine creation.

Prototype 1A: My Water

Prototype 1A (seen in figure 3.8) served as a lo-fi representation of the current shower routine creation function in the My Water app. It was designed to closely mimic the app and was fitted with almost all of its functionality, with the most notable difference being the lack of support for scrolling through the routine being created. Instead, all added instructions were simultaneously visible in the routine overview.

Prototype 1B: Iconography

In order to make the interface more appealing, iconography was introduced with this prototype. Since previous user testing indicated that users were confused by several of the commands available in the original interface, the amount of available commands to add were limited to three, as presented in figure 3.9: Water flow (indicated by a blue drop of water on a green background), Temperature (indicated by "ºC" on a blue-red gradient background), and Time (indicated by the picture of a clock on an orange background. The colors of these commands were chosen to be distinct in order to allow a clearer overview of a sequence of commands upon routine creation.

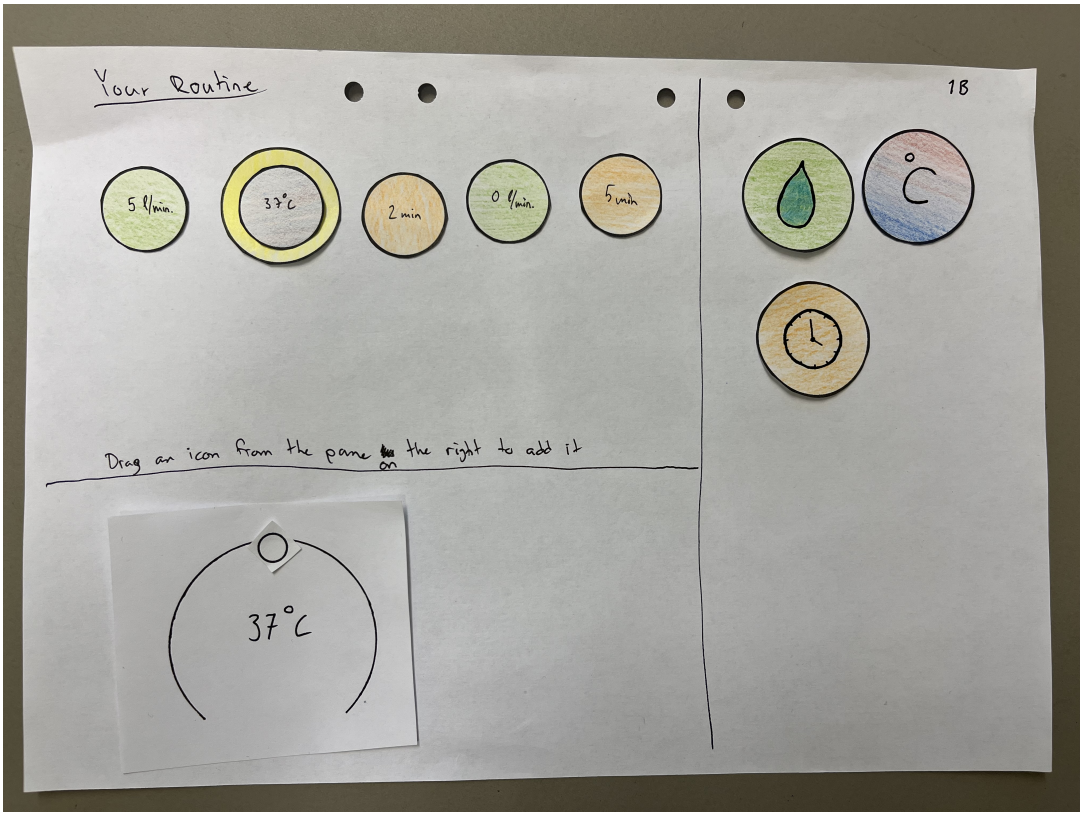

Figure 3.9: Prototype 1B: Iconography. Picture taken in the middle of routine creation.

Adding a command from the command pane can be done in two ways: by simply tapping the command icon in the command pane, or by dragging it onto the view pane (as indicated by the informative test at the bottom of the view pane). Upon adding a command, an icon of the same color is added to the view pane, while the original command returns to the command pane (if dragged). This functionality is present in many drag-and-drop interfaces and was chosen because of its possible familiarity to the users.

Upon adding a command to the view pane, the new command is automatically selected (as indicated by the yellow highlight), and a corresponding dial appears in the dial pane. This dial allows the user to adjust the setting of the command (flow, temperature or time), and any adjustments are reflected in both the dial pane, and on the selected icon in the view pane.

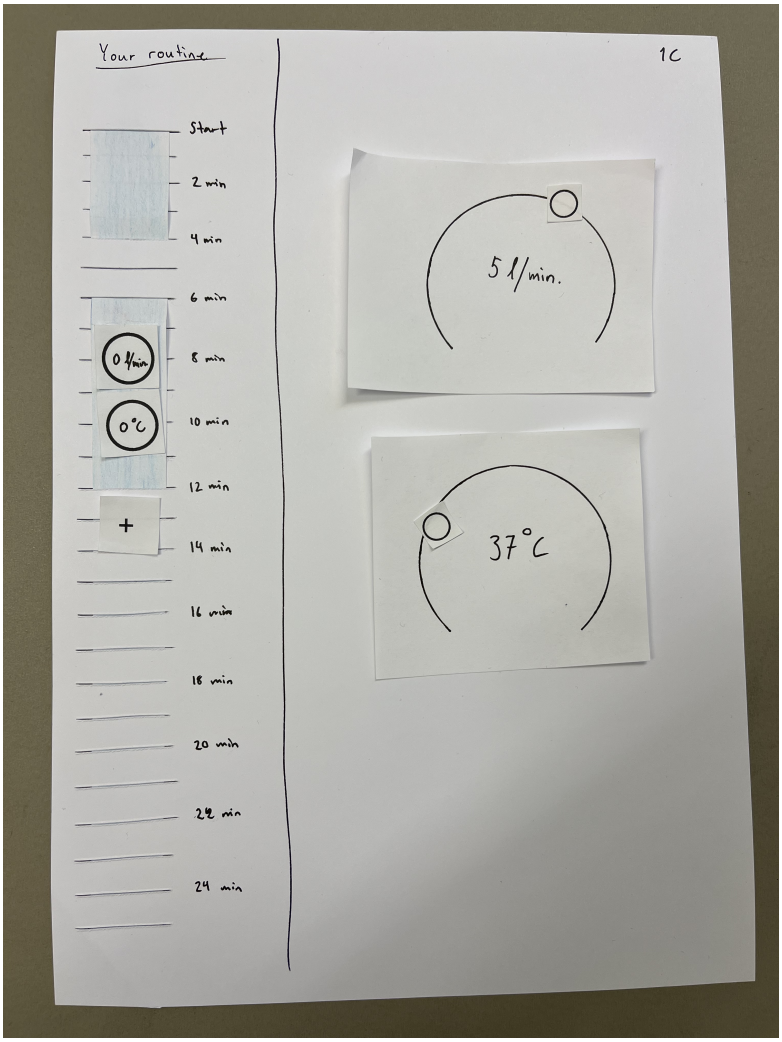

Figure 3.10: Prototype 1C: CalendarBlocks. Picture taken in the middle of routine creation.

Prototype 1C: CalendarBlocks

Like My Water, the core of CalendarBlocks was the vertical arrangement of instruction blocks. However, the blocks in CalendarBlocks were aggregate versions of the ones in My Water – each block consisted of three values: temperature, flow, and duration. The blocks were placed on a vertical timeline, with time stamps for every two minutes of the routine elapsed. Initially, the timeline would be empty save for a plus symbol at the top. By pressing said symbol, the user could create a new block with default values below the bottom-most block of the timeline, or at the top should there be no existing blocks. The plus symbol would then be moved to right under the newly created block. By pressing a block, two dials, one for temperature and the other for flow, would show up in a large view next to the timeline. The duration of each instruction was represented by the height of the block, and could be manipulated by dragging either end of the block. By pressing the body of a block, that block would be selected, and its temperature and flow values would show on its body. In figure 3.10, a routine in the middle of creation is shown.

Prototype 1D: Pin-Graph

As a result of studying the systems similar to the shower routine creation process (as presented in section 1.5.1, with particular regards to the FL Studio application), a prototype based on adding and manipulating nodes on a graph was created. In this prototype, users were encouraged to manually handle the adjustment of a graph by moving pins on a corkboard. At the start of routine creation, only the start- and end nodes were present drawing a straight line of string between them. By adding and moving pins to the interface, users were allowed to adjust the string representing the graph accordingly.

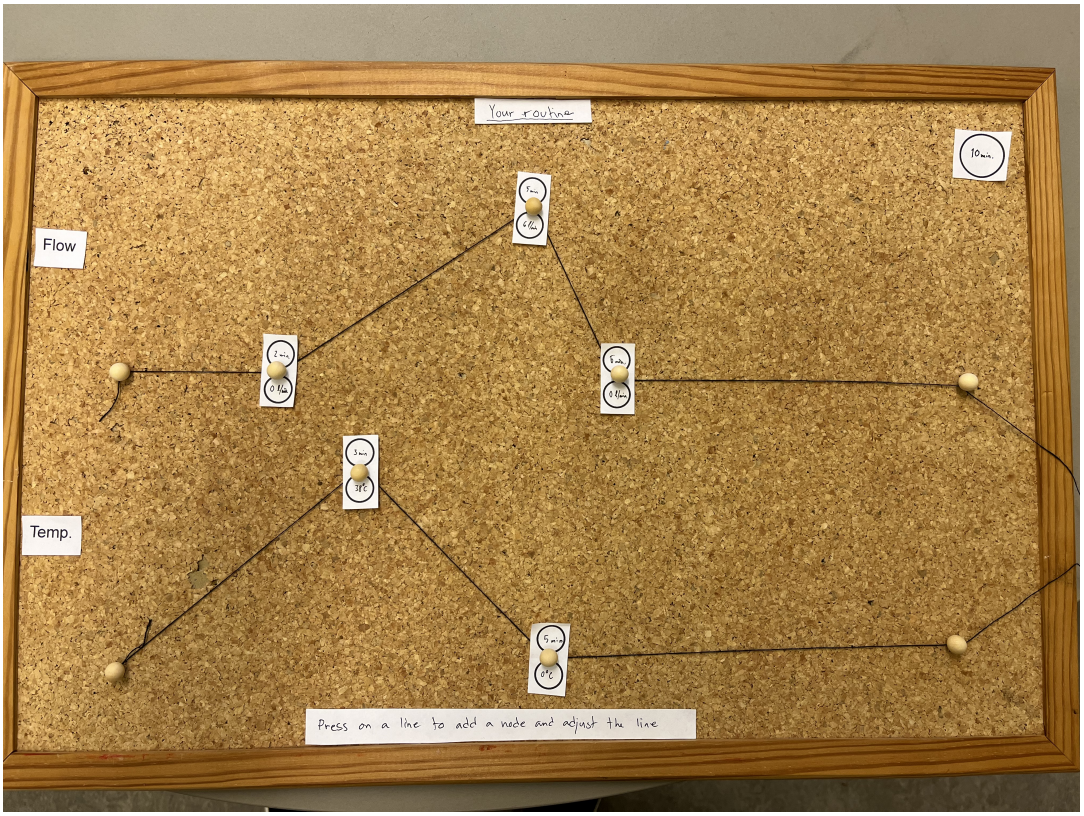

Figure 3.11: Prototype 1D: Pin-Graph. Picture taken in the middle of routine creation.

Also present in the view at routine creation start were the Routine Name Label ("Your routine"), the Graph Labels ("Flow" and "Temp."), the Instruction Label ("Press on a line to add a node and adjust the line"), as well as the Routine Time Label ("10 min"), all seen in figure 3.11.

As pins were adjusted, so was values depicting time and flow/temperature for the respective graphs (as seen depicted by pieces of paper with circles containing the values). Users were also allowed to manually enter specific values for each circle by pressing on them, and then adjusting a pop-up dial (as seen in figure **??**). Adjusting the values via the dial in this way automatically updated the corresponding pins placement on the board.

The Routine Time Label was also interactable, by pressing on it. Users who did were presented with a dial allowing to adjust the total time of their shower routine. Any adjustments made on this dial also adjusted the time values of any nodes present on the graphs, updating

them to a value corresponding to their placement on the graph in relation to the total time value (i.e. if the time was increased from 10 min to 20 min, all time values on nodes would also be doubled).

For simplicity's sake, and to allow quick live-adjustment of the prototype in testing, all values (time, flow, and temperature) were presented as whole integer values.

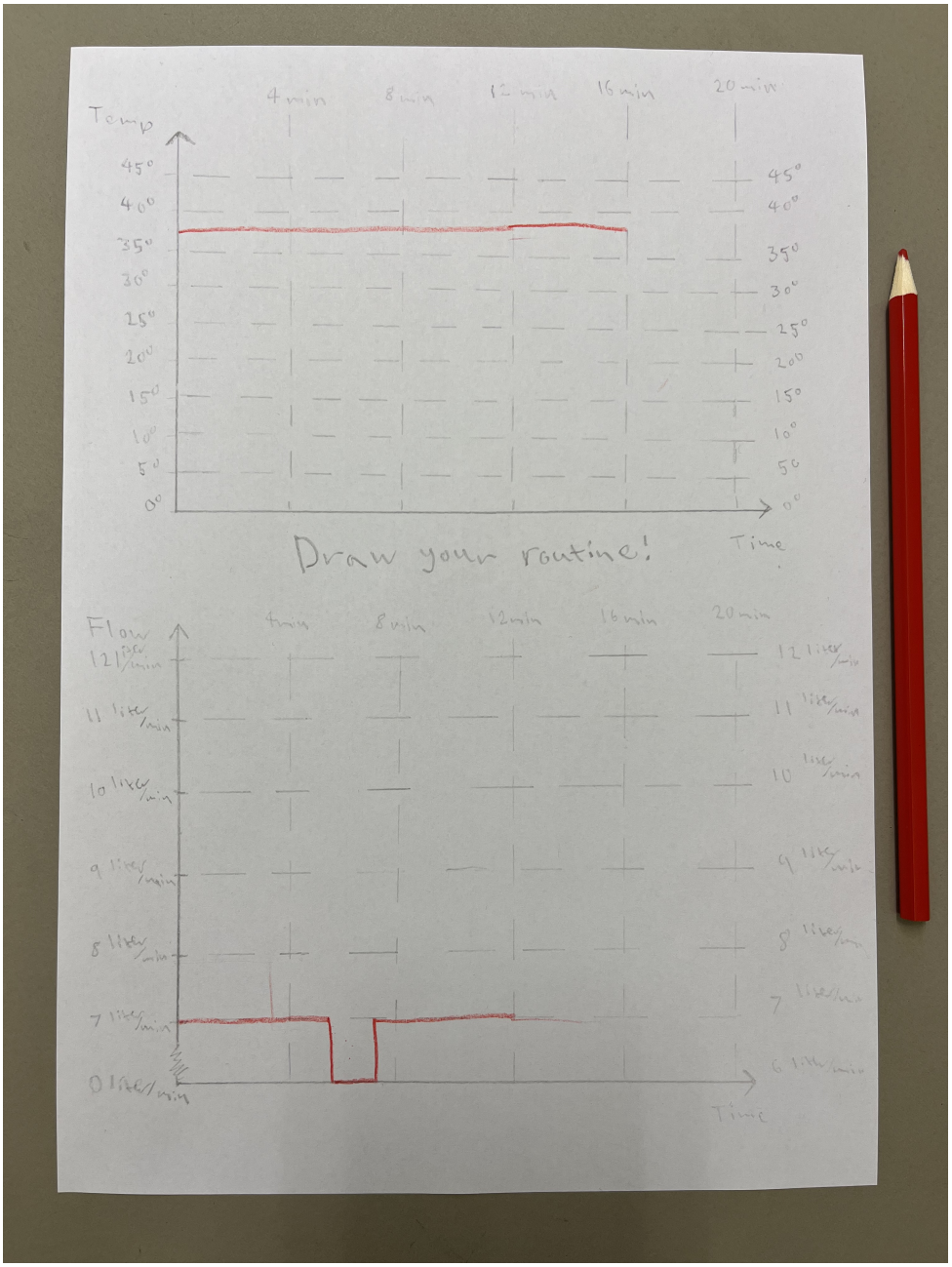

Figure 3.12: Prototype 1E: FreeDraw. Picture taken in the middle of routine creation.

Prototype 1E: FreeDraw

The FreeDraw prototype was comprised of a single view consisting of two graph canvases, one for temperature and one for flow, for the user to draw on with a red crayon.

To facilitate precise drawing, each canvas was fitted with values on the axes and a grid consisting of lines corresponding to said values. In the upper graph, the y-axis represented temperature, with values ranging from 0°C to 45°C in increments of 5°C. In the lower graph, the y-axis represented flow, with values ranging from 7 liters/minute to 12 liters/minute, with a jump to 0 liters/minute at the bottom of the axis. In both graphs,the x-axis represented time, with values ranging from 0 minutes to 20 minutes, with a grid line for every 4th minute.

When dragging a finger across either canvas, a red line would appear representing what value the corresponding *thing* would assume at a given point in time elapsed since routine start. The red line would be an approximation of the user input; curves and zigzags would result in straight segments. Tapping anywhere on a canvas would produce a straight line from the x-axis to where the tap occurred.

3.2.2 Testing

To evaluate the potential of the different prototypes and deduce which of them to develop further, ten test sessions with ten different participants were conducted in this iteration. Each session consisted of five tests – one for each prototype.

Test Structure

At the beginning of each test session, the participant was given a brief background of the project and introduction of the concept of shower routines, without revealing any information about the prototypes. They were then prompted to describe their typical shower routine. If the routine was deemed so simple that recreating it would not provide any insight into the usability of the prototypes, the participant was instructed to recreate a default routine instead. The default routine entailed turning the water on at 5.0 liters/minute at a temperature of 37°C, showering for three minutes, then turning the water off for one minute while shampooing, and finally turning the water on at 8.0 liters/minute at a temperature of 39°C for two minutes. Regardless of what routine the participant was instructed to recreate, they were to recreate the same routine with every prototype.

Participants were given different prototypes to start with, and would then proceed by testing the prototypes in alphabetical order; if a participant were to start with prototype 1B: Iconography, the test order would be 1B: Iconography, 1C: CalendarBlocks, 1D: PinGraph, 1E: FreeDraw, 1A: MyWater.

Each test was timed — without the participant's knowledge not to induce any stress — and after completion it was noted whether the participant managed to recreate the routine or not. The criteria for acceptable recreation were fairly lenient; as long as the created routine would not be perceived as vastly different to the goal routine upon showering, it was considered a success. Creation would typically be deemed unsuccessful if there were significant discrepancies between the created routine and the goal routine in regard to temperature or flow, number of pauses, or duration of transitions.

After each prototype test, the participant was asked how difficult they found using the

prototype, how difficult they found the completed routine to overview, and if they had any other thoughts in regard to the tests or potential improvements. Follow-up questions were asked until no new information was provided. After all five tests had been completed, the participant was prompted to order the prototypes in order of general preference.

Test Participants

There were 10 test participants, of which four were women and six were men. Participants were between 22 and 38 years old and had different professional backgrounds. Four participants did not have any significant programming experience, while the other six did. Three participants had also participated in previous tests of the My Water app during the predesign analysis described in section 3.1.2. Participants were recruited through message apps or in person.

3.2.3 Results and Analysis

Most participants did not provide a sufficiently complex shower routine of their own, and were instead tasked with recreating the default routine. To be considered sufficiently complex, the routine would have to include at least one change of temperature, one change of change water flow, and one pause (as in turning the water off and then on again.)

Prototype 1A: Current App

Positives:

- Seven participants, six of which having programming experience, found routine creation intuitive
- Seven participants, six of which having programming experience, found the finished routine easy to overview

Negatives:

- Three of the four participants with no programming experience did not find routine creation intuitive
- Seven participants had some difficulty understanding the difference between commands "Pause" and "Wait" and how to use them
- Six participants found having to switch view in order to add commands cumbersome
- Five participants were unsuccessful in recreating their routine
- The prototype was ranked the lowest on average
- The prototype was the slowest on average (as can be seen in Figure 3.13)

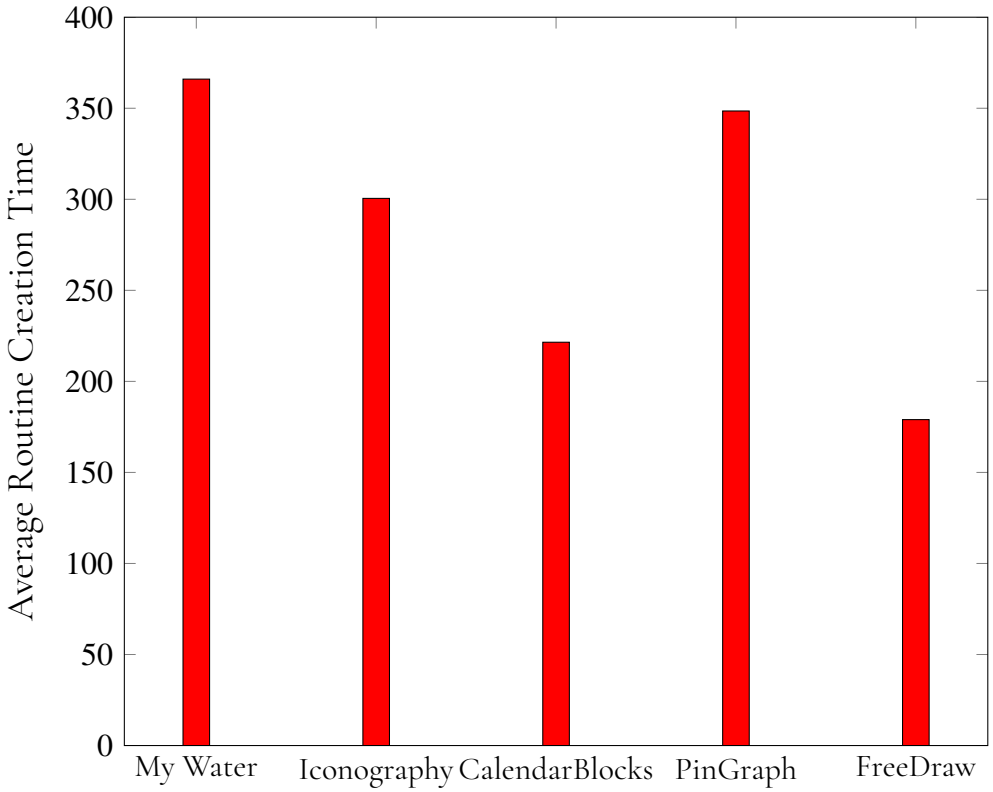

Figure 3.13: Average routine creation time for the lo-fi prototypes in Iteration 1.

The lo-fi representation of the current app did not perform particularly well. It received an average ranking of 3.9, the lowest of any prototype by a significant margin, a success rate of merely 0.5, and the longest average completion time.

A decent number of testers encountered difficulty in understanding the commands "Wait" and "Pause", and often confounded one for the other. A few testers never added any "Wait" commands at all. Several testers did not add a "Shower off" command at the end to the routine, although this was not deemed a failure on its own, as the need for this command can be considered questionable.

Most testers found having to switch between views to add new commands cumbersome and tedious.

Prototype 1B: Iconography

Positives:

- Nine participants found routine creation intuitive
- Seven participants found the finished routine easy to overview
- Seven participants were successful in recreating their routine
- The prototype was ranked the second/third highest on average, together with PinGraph

Negatives:

- Three participants found the interface difficult to overview

Iconography performed moderately well. It achieved an average ranking of 3.1, generally being ranked second through fourth. The average ranking tied for second/third best with that of PinGraph. Iconography scored in the middle in regard to both speed and success rate.

Participants enjoyed the ample use of color in the prototype.

Some participants expressed difficulty in understanding how commands were connected in the routine pane. Most of the confusion seemed to arise from the time symbol and whether it set the duration of symbols to its left or symbols to its right. These participants suggested some form of grouping of symbols as a potential solution.

Prototype 1C: CalendarBlocks

Positives:

- All 10 participants found routine creation intuitive
- All 10 participants found the finished routine easy to overview
- Nine participants were successful in recreating their routine
- The prototype was ranked the highest on average
- The prototype was the second fastest on average

Negatives:

- Users found it slightly confusing to add a block with a flow value of zero in order to pause

CalendarBlocks outperformed the other prototypes in virtually every regard. It attained an average rank of 1.7, the highest of all the prototypes with a great margin. Six testers ranked it first, and no tester ranked it lower than third. Only one tester was unsuccessful in recreating their routine, resulting in the highest success rate of any prototype, and the prototype achieved the second shortest average routine completion time.

Testers found the interface intuitive and rarely had any difficulty in using it. Almost every user considered the finished routine easy to overview and expressed no difficulty in visualizing it.

Some users expressed a desire for the blocks to occupy a larger part of the view, as they were the main focus in the routine creation.

Only one user found out about leaving a space open in order to add a pause to the routine. Other users decided to add a block with flow value zero in order to achieve the pause, even though some of them discovered the ability to drag and drop blocks. In order to make it easier for users to discover the possibilities of this design, better signifiers should be given to indicate aforementioned possibilities.

Prototype 1D: PinGraph

Positives:

- Six participants found routine creation intuitive

Negatives:

- Six participants found the finished routine somewhat difficult to overview
- Seven participants were unsuccessful in recreating their routine

PinGraph achieved an average ranking of 3.1, tied for second best with Iconography. It ended up a close second to last in terms of speed, and scored a success rate of 0.3 — the lowest of any prototype.

Many participants were initially confused when presented with the prototype, but most recovered fairly quickly and then proceeded without encountering any major difficulties. Many participants did however not realize that a downward sloping graph would result in a slow decrease in temperature or flow rather than a quick cutoff, which often resulted in failure to recreate the routine. A few participants found having to adjust the temperature and flow lines separately annoying, and the need for the existence of the flow line was often questioned.

Prototype 1E: FreeDraw

Positives:

- Eight participants found the finished routine easy to overview
- Eight participants were successful in recreating their routine
- Two participants, neither of which having programming experience, considered the prototype their favorite
- The prototype was the fastest on average

Negatives:

- The prototype was ranked second lowest on average

FreeDraw scored an average ranking of 3.2, the second worst of any prototype. On the other hand, the second most users managed to recreate their routine using the prototype, and it was the fastest prototype by a decent margin.

FreeDraw proved to be the most divisive of the prototypes. It achieved both several top and bottom rankings, while being ranked third, i.e. in the middle, only once. participants with little to no programming experience tended to rank the prototype high, while participants with significant programming experience usually ranked it low.

A few participants misunderstood the intended use of the prototype completely, and started coloring in the grid instead of drawing lines. Most participants voiced some complaint over the touch mechanics of the prototype. The complaints typically regarded what

were to happen upon a quick touch of the canvas or upon drawing over existing lines. A few testers expressed a desire to manipulate existing lines by dragging them around. Most testers found the temperature interval to be too great, and many testers found getting the right temperature unnecessarily tricky.

Success Rate of Prototypes

Figure 3.14 shows the success rate of the different prototypes of the first iteration. A success entailed that the test participant managed to re-create their routine (or the default routine, where applicable).

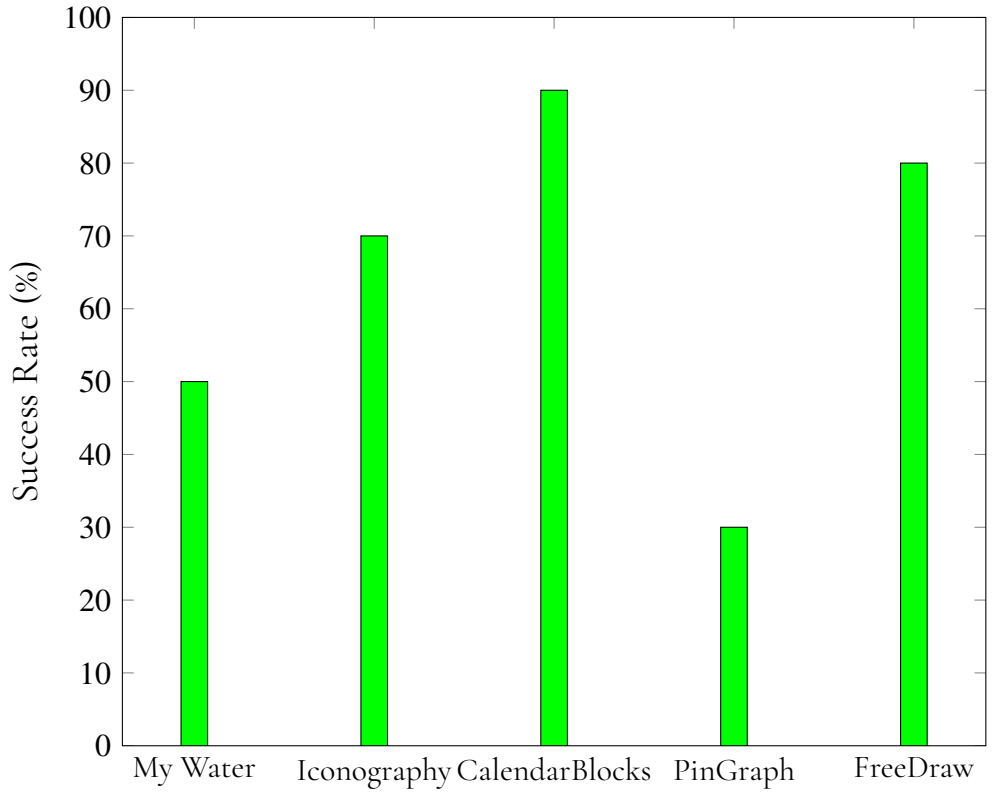

Figure 3.14: Success rates of the lo-fi prototypes in Iteration 1.

General Feedback

Most participants expressed difficulty in imagining how they would perceive any given water temperature or level of water flow. Furthermore, most participants completely lacked any frame of reference for liters/minute as a unit. Importantly, few participants had any habit of adjusting water flow when showering, and expressed indifference to the functionality of making finer adjustments to water flow.

Table 3.1 shows the ranking scores of the prototypes in this iteration. A low score is equal to a higher ranking by the test participants.

Table 3.1: Average ranking of the lo-fi prototypes in Iteration 1.

Prototype	My Water	Iconography	CalendarBlocks	PinGraph	FreeDraw
Average Ranking	3.9	3.1	1.7	3.1	3.2

Result Validity

As some prototypes had not been given as much thought as the rest, the responses to some actions taken by the testers had to be improvised. Those prototypes (mainly 1D and 1E) might therefore have been put at an unfair disadvantage, and could possibly have performed significantly better with just slight alterations.

Time may have been a dubious measure of prototype quality. While users would be more likely to grow bored with a more time-consuming application, even if the creation process is slow, it does not have to be repeated, since routines are saved. Moreover, the tests showed that difficulty using a prototype was not always the cause of long test times. Some users simply found some prototypes more interesting than others, therefore having more to say about them. Test times were generally inconsistent even when looking at a specific user, as they could be significantly slower than average when using one prototype, while being much faster when using another.

The instructions for ranking the prototypes were strictly enforced in that each prototype had to be assigned a number, even in the case where the tester expressed a desire for ties, which was not uncommon. Hence, the final tally does not reflect any nuances in ranking; a number one ranking could represent a vast superiority over the rest of the prototypes, but just as well merely a slight advantage over the runner-up.

Some prototypes allowed for flow values within the interval 0-7 liters/minute in addition the original interval of 7-12 liters/minute. In the case of CalendarBlocks, to add a pause for shampooing, many users set the flow to 0 before ever attempting to add an empty space between blocks. This may have swayed results in favor of CalendarBlocks, as those testers may have encountered difficulty in adding an empty space.

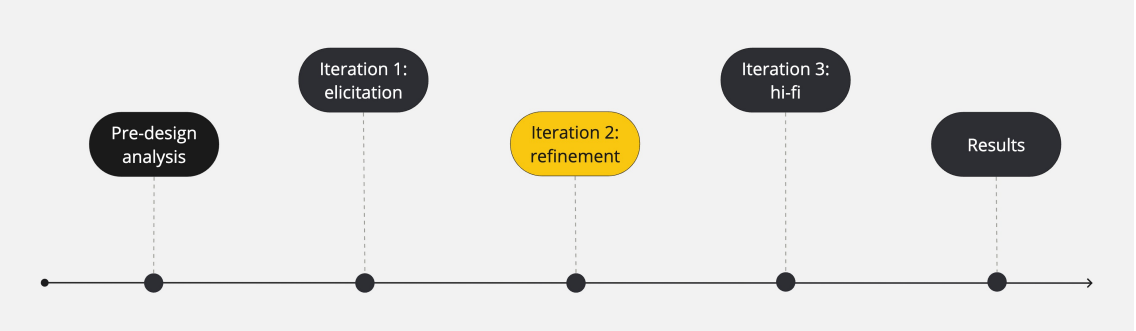

Figure 3.15: Showing what part of the design process is presented in this section.

3.3 Iteration 2: Refined Lo-Fi Prototypes

As opposed to the explorative approach of the first iteration of the design process, the second iteration focused on refining the prototypes into more well-developed interactive systems based on feedback gained from user testing. During this iteration, only two prototypes were created and tested, derived from and comprised of the previous five.

3.3.1 Design of Prototypes

During testing of first iteration prototypes, it became clear that users grouped the prototypes into two groups: the "command-oriented"-group, and the "graph-oriented"-group (our definitions, not from users). In the first group, the prototypes using a graphical unit to represent a change in shower parameter values (essentially a "command") were deemed similar and comparable by users. These include prototypes 1A, 1B and 1C, with the graphical unit being, respectively: the different command paper slips (1A), the different command icons (1B), the calendar blocks (1C). The interaction of the prototypes in this group all centered around manipulating values linked to these units by adjusting some kind of parameter accessed by interacting with the element itself.

In the other group, interaction with elements of the interface instead adjust, by users deemed, "adjacent" values. The remaining two prototypes, 1D and 1E, both present a graph-like interface where individual "nodes" adjust not only values directly linked to the node itself, but also connecting lines. While some users did not seem to understand the affordances (see section 2.2.9) of these prototypes, others seemed to greatly enjoy the presentation and ease-of-use of them.

Continuing with developing designs for the second iteration thus encouraged the development of two distinct prototypes, each delving further into the interactions of these two groups. In order to achieve successful designs, it was decided that the most appreciated parts (by the users) of each prototype should be included in the new designs. These choices are outlined further in the following sections.

Furthermore, since the lo-fi version of the My Water app did not perform well in the tests, and since it was planned to be used as a comparison for the hi-fi prototype developed in iteration three, it was decided not to be prototyped further beyond this step.

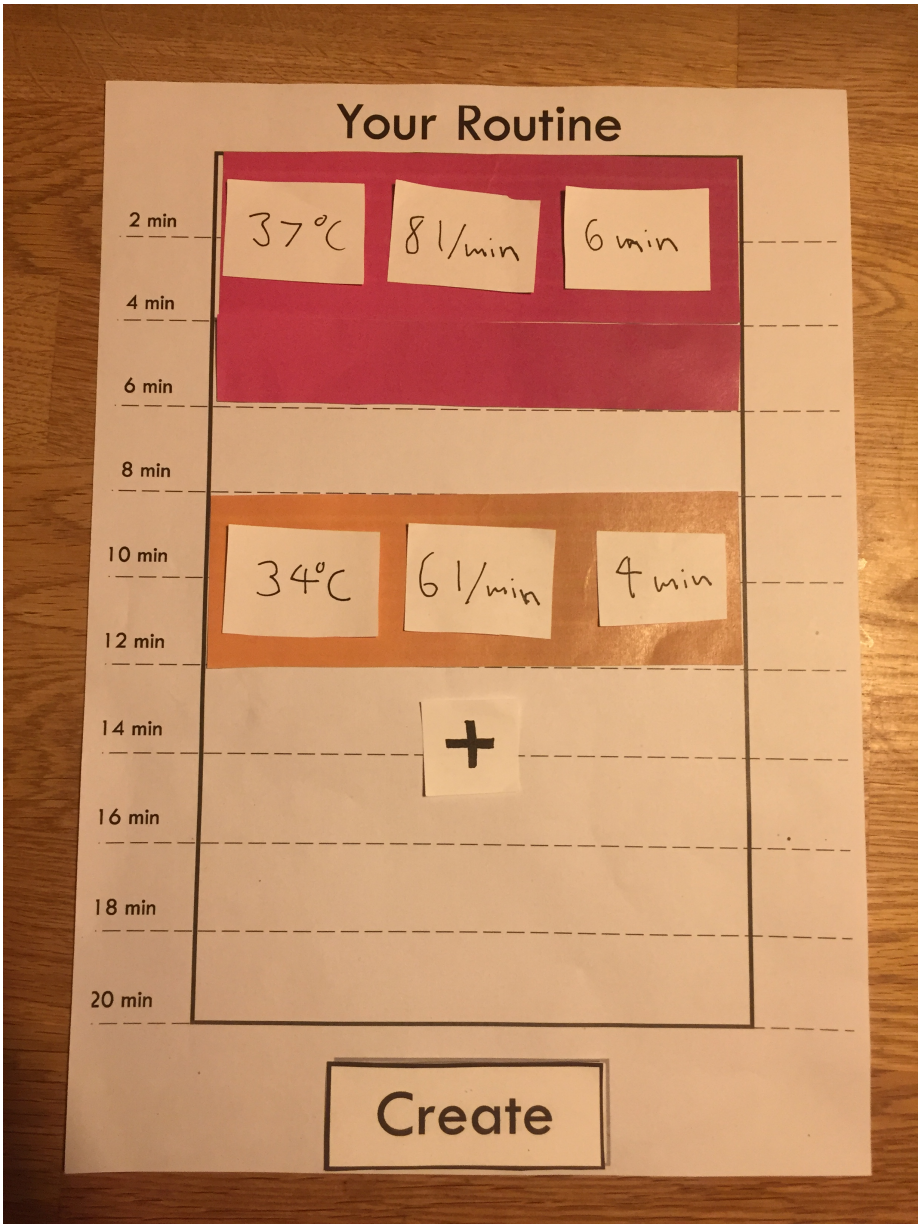

Figure 3.16: Prototype 2A: Blocks. Picture showing the main pane, taken in the middle of routine creation.

Prototype 2A: Blocks

This prototype primarily incorporates elements from the 1B and 1C prototypes. Since prototype 1C performed best in virtually every aspect during tests, it became the entry-point of design for this prototype. Since the main positive aspect of the 1B prototype was its use of color and not necessarily the use of icons, it was decided that the iconography should be left behind, but that the coloration should withstand in further development.

Feedback gained from the user testing in the first iteration showed that users were confused about the "main pane" of the 1C prototype (the pane containing the blocks shown in a time-line) being so much smaller than the "adjustment pane" where the adjustment dials were shown. Users felt that the most important part of the interface, being the time-line and

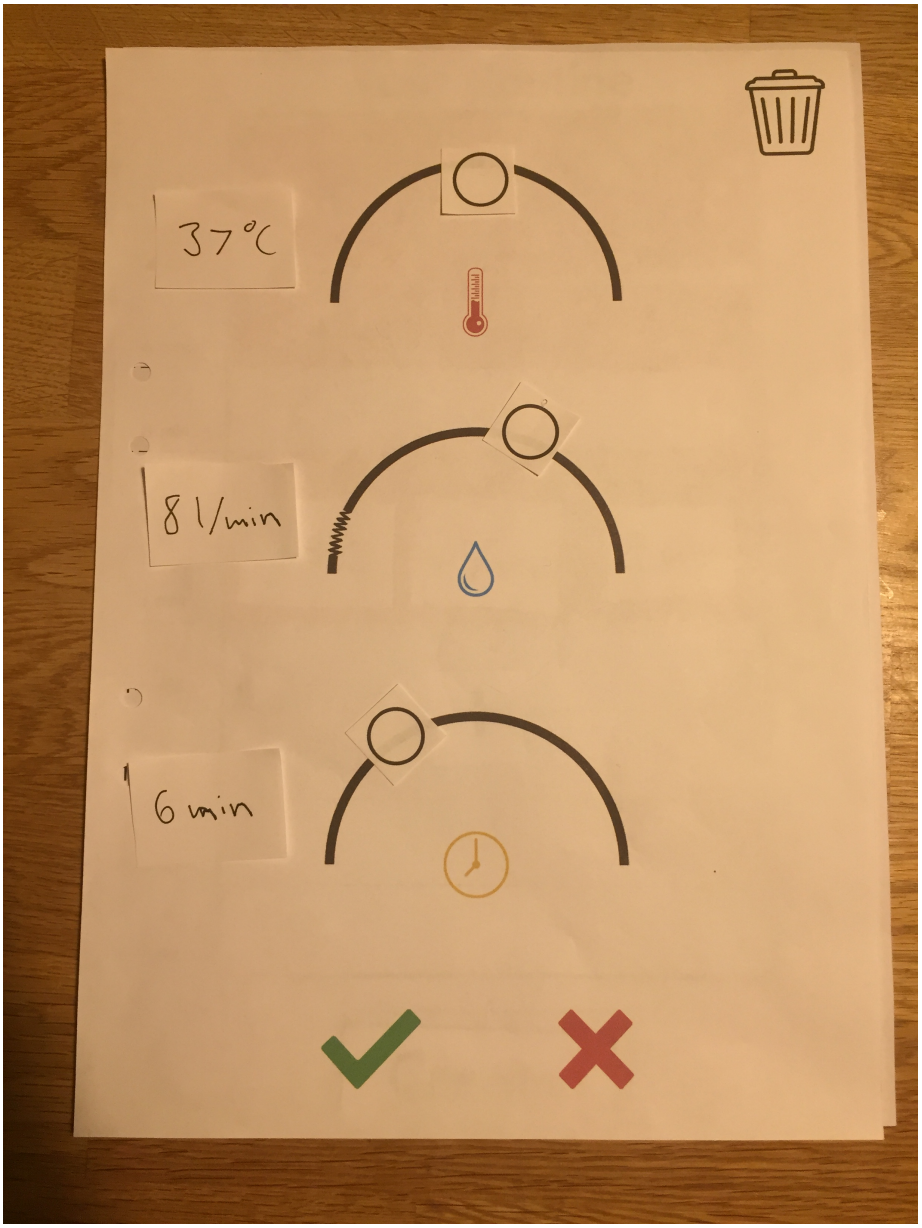

Figure 3.17: Prototype 2A: Blocks. Picture showing the adjustment pane, taken in the middle of routine creation.

blocks, should fill the largest part of the view. For this prototype, adjustments was thus made to let the main pane (seen in figure 3.16) fill the entire view while creating routines. The adjustment pane (seen in figure 3.17) was instead presented as an overlay over the main pane when users interacted with certain unit elements, to allow them to adjust the desired values. An additional minor change to emphasize that the flow value of 0 meaning no water (or "pause") was added: a visually marked cut-off point to the flow dial (a zig-zag pattern shown in figure 3.17). When the user releases the indicator at any point from the cut-off point and "below", the indicator snaps to the lowest value. At the same time, the temperature graph is greyed out, indicating that it is inactive.

Because of this the adjustment pane was also given new buttons in order for users to

confirm or cancel their changes. These buttons were designed with common user concepts in mind, as presented by users in testing. A green checkmark for accepting changes and a red cross for reverting changes were the design choices that were deemed most in-line with users mental models.

Since several users expressed a wish to be able to remove blocks from the time-line, and since that functionality was not included in prototype 1C, two options for removing blocks was added: one additional button in the adjustment pane, and an area to drag blocks to in order to remove them from the time-line (only shown when dragging). Both of these options were given the same graphical design, in order to link them through the users perceptions. Again, in order to use an already present mental model of users, a trash-can icon was used to communicate the possibility of removing (trashing) a block.

Ideally, block color would be decided based on temperature; colder blocks would be bluer, and warmer blocks redder. This was however quickly dismissed as too difficult to implement in a lo-fi prototype, and any attempt at doing so would likely have resulted in inconsistency. Blocks were instead colored purple, orange, or green. The objective of this was to disassociate color and temperature in the prototype entirely, which was considered less confusing than an inconsistent relationship, while also maintaining ease of distinguishing between blocks.

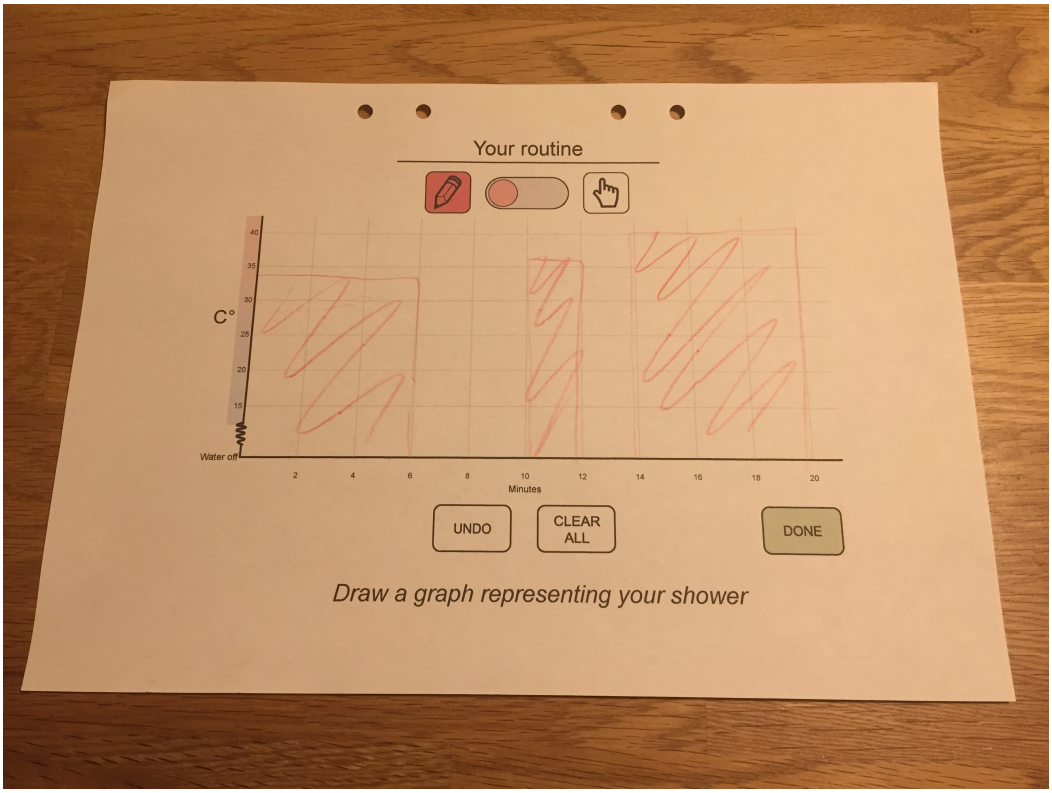

Figure 3.18: Prototype 2B: Graph. Picture showing a finished routine, in the "input mode".

Prototype 2B: Graph

In testing, users expressed an appreciation over the graphical look and ease-of-use of the 1E and, in particular, 1D prototypes. The process of graphically drawing their shower provided

users with a fun, new and intuitive experience. Because of the general excitement over the free-draw aspect in prototype 1E, the Graph prototype was designed around letting users draw their graphs freely using a pencil (in later, digital implementations a finger could be used instead).

Since all users expressed some confusion or surprise about having to draw two graphs in prototype 1E, and since all users expressed severe confusion about the water flow values in general throughout testing, the decision was taken to remove the control of water flow entirely from this prototype. Instead, water flow in this prototype is activated when the temperature is above zero degrees Celsius, and deactivated at any other time. Users control this by drawing their graph to or below a zero degree cut-off point in the graphs y-axle. In this way, users need only input one graph (depicting change in temperature) in order to program their routine. In figure 3.18, a completed routine can be seen.

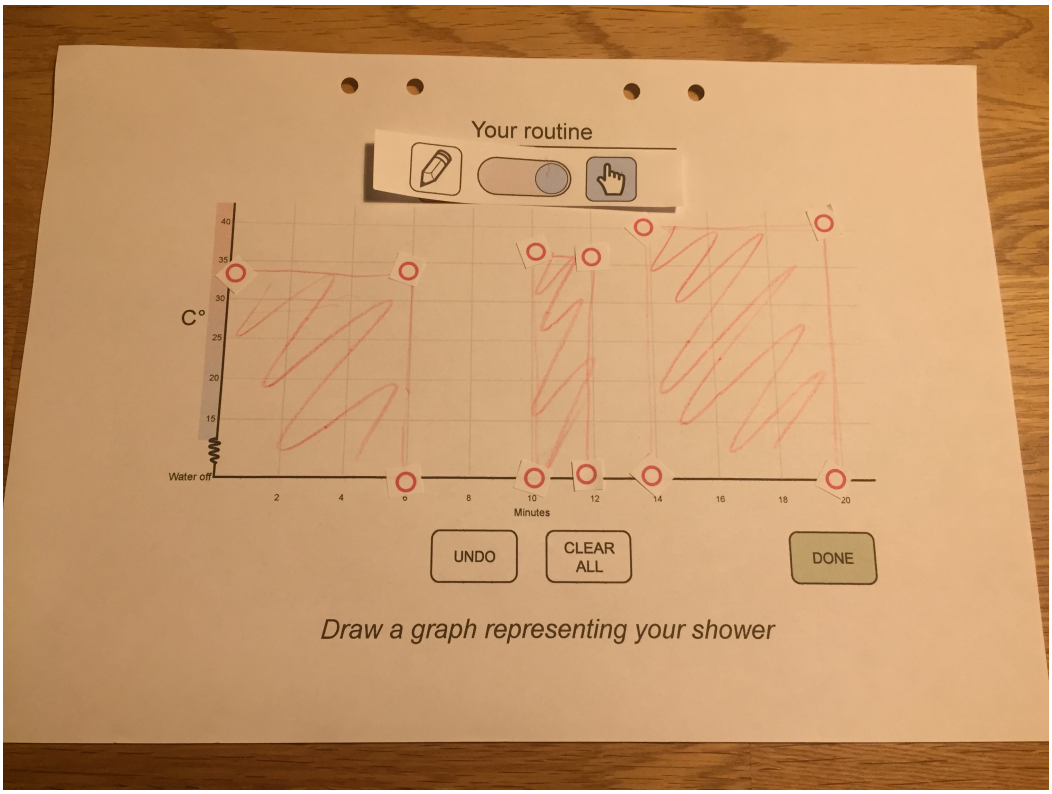

Figure 3.19: Prototype 2B: Graph. Picture showing a finished routine, in the "edit mode".

Many users were confused about the nodes (and how to interact with them) in the 1D prototype, but all users expressed desire to be able to edit their graphs in both 1D and 1E. When users were prompted to try to edit their graphs in these prototypes, many mistakes were made, and many users failed. Because of this, a clarity of how and when to edit was developed for this prototype by adding a "mode-button" to the interface. This button changes mode from input (depicted by a pen), to editing (depicted by a hand). While in input mode (as seen in figure 3.18), all actions by the user overwrites previous input values, if any. On the contrary, while in edit mode (as seen in figure 3.19, note the change in the mode indicator right below the "Your routine" title) the user cannot add any new lines or nodes to the graph by drawing, but they are able to select (by pressing on) and adjust (by dragging) existing lines

and nodes. Adjusting a line corresponds to adjusting the two nodes connected by the line simultaneously. Additionally, while a node is selected (see figure 3.20) it can be removed by pressing an "X" button near the node, connecting the previous and next node in the graph with a new line, which is then automatically selected. Additionally, while a line is selected (see figure 3.21), a node can be added to the middle of that line, splitting it in two. Doing this selects the new node.

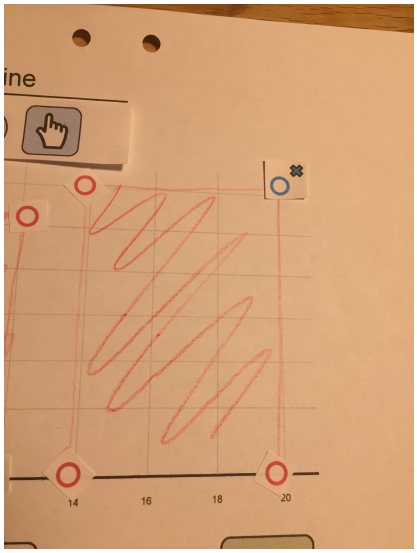

Figure 3.20: Prototype 2B: Graph. Picture showing a selected node in edit mode. Note the "X" icon allowing the removal of the node.

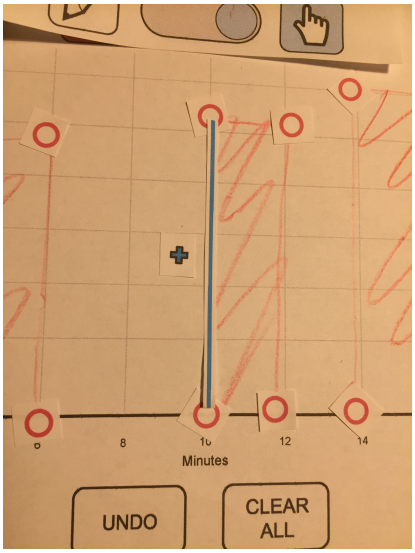

Figure 3.21: Prototype 2B: Graph. Picture showing a selected line in edit mode. Note the "+" icon allowing the adding of a node.

3.3.2 Testing

To evaluate the potential and performance of both prototypes and deduce which of them to develop further, eight test sessions with eight different participants were conducted in this iteration. Each session consisted of two tests – one for each prototype.

Test Structure

At the beginning of each test session, the participant was given a brief background of the project and introduction of the concept of shower routines, without revealing any information about the prototypes. They were then given a standard shower routine to re-create in the interfaces. This routine entailed showering at a temperature of 37°C for four minutes, then turning the water off for three minutes, and finally showering at a temperature of 40°C for six minutes.

After creating the first shower routine, participants were asked to change their routine to the following: showering at a temperature of 34°C for six minutes, then turning the water off for four minutes, showering at a temperature of 36°C for two minutes, then turning the water off for three minutes, and finally showering at a temperature of 40°C for six minutes.

Participants were given different prototypes to start with, alternating between prototypes 2A and 2B.

Each test was timed — without the participant's knowledge not to induce any stress — and after completion it was noted whether the participant managed to recreate the routine or not. The criteria for acceptable recreation were fairly lenient; as long as the created routine would not be perceived as vastly different to the goal routine upon showering, it was considered a success. Creation would typically be deemed unsuccessful if there were significant discrepancies between the created routine and the goal routine in regard to temperature, number of pauses, or duration of transitions.

After each prototype test, the participant was asked how difficult they found using the prototype, how difficult they found the completed routine to overview, and if they had any other thoughts in regard to the tests or potential improvements. Follow-up questions were asked until no new information was provided. After both tests had been completed, the participant was prompted to order the prototypes in order of general preference. The participants was then asked a final question if they would consider using any of the prototypes instead of traditional shower controls.

Test Participants

There were eight test participants, of which one was a woman and the other seven were men. The participants were between 20 and 33 years old and had different professional backgrounds. Three of the eight participants did not have any significant programming experience, while the remaining five did. Two participants had also participated in the previous tests of the My Water app during the pre-design analysis, and both of these participants had also participated in the first iteration tests. Participants were recruited through message apps or in person.

3.3.3 Results and Analysis

Every test participant preferred Blocks to Graph.

Graph was subject to fewer complaints than several of the lo-fi prototypes, and returning test participants struggled significantly less than they did on average before.

On the other hand, Graph was considered harder to use than Blocks, and its finished routines were considered more difficult to overview. Participants often attempted to manipulate nodes when in draw mode, and four participants explicitly complained about having to switch tools. Furthermore, participants often found nodes to behave unexpectedly, especially when creating or removing them, and participants consequently often had to put effort into correcting mistakes. There was an expectation of being able to manipulate blocks by pressing their body,

In general, participants considered Graph to be too advanced for the task at hand, dismissed much of its functionality as unnecessary and confusing, and often expressed a desire for a simpler interface.

Feedback from testing indicated strongly that users would want an example routine to study or base their own routines on.

During testing, the amount of errors made by the participant was recorded, for each prototype separately. The results are shown in table 3.2. The errors marked with ' * ' were ex-

pressly deliberate by the participant in order to provoke the prototype. These errors are thus not included in the average, as they were performed after the routine had been successfully created.

Table 3.2: Errors made during routine creation during user tests in Iteration 2. Errors marked with ' * ' were expressly deliberate by the participant.

Participant nr	2A: Blocks errors	2B: Graph errors
P 1	0	2
P 2	1*	10*
P 3	1	2
P 4	1	5
P 5	0	1
P 6	3*	1
P 7	0	2
P 8	0	1
Average	**0.25**	**1.75**

Blocks

Positives:

- Users expressed that the interface felt intuitive and easy to manipulate.
- All users managed to create and adjust the routines to a satisfactory result.
- All users expressed ease of overview during and after routine creation.
- Time indicators on the left were verbally appreciated by several users.
- Clearly preferred by all users.

Negatives:

- Slightly slower on average than prototype 2B.
- Some users were confused about how to add a pause in the flow.
- Although preferred, most users expressed that they would not use the routine creation feature instead of adjusting values in the shower by hand (discussed below, and in further detail in section 4.2).

This was the favorite prototype of all users during tests. Many of the users expressed that the design reminded them of calendar apps and school schedules, a conceptual model corresponding to the intention of the design. All users manipulated the interface with ease, and even though some expressed minor confusion over certain aspects (mainly the position of the '+'-sign), the users always tried the correct action to confirm their suspicions/rectify their confusion immediately after expressing it.

Some users suggested that the interface should be stationary in the shower rather than in an external app.

Graph

Positives:

- Slightly faster on average than prototype 2A.
- Fun to use.

Negatives:

- Many differing opinions regarding selection and adjustment of nodes were expressed. Different users seemed to have different mental models of what the signifiers in the design entailed.
- Seven times more errors were made compared to prototype 2A.

Half of the users expressed that this prototype was fun to use. All users expressed to some degree that the prototype was confusing, unexpected or too advanced for the task at hand. Some users expressed an appreciation of the granularity of this prototype, but simultaneously expressed that they probably would never use that granularity.

The indicated values on the axes in this prototype seemed to slightly confuse users. Values for every whole integer value for degree/minute on the axes was asked for, instead of the benchmark values presented. Several users expressed that they did not want to do math in the shower.

No user seemed to miss the ability to control flow values in this prototype, indeed some of them expressed that it was nice to not have to enter values for it, since they did not understand the values anyway. Those who did express anything about the flow values stated that they always wanted to shower with flow set to its maximum value.

Notably, when users were asked whether they would consider using the shower routine creation feature, all users expressed reluctance at the prospect. The ease of use of traditional shower knobs/levers was commented to be sufficient, and the idea of pre-programming a shower routine seemed alien to their needs. Most users communicated that they often did not know precisely how long, or how hot they would like their shower to be when entering it. They also stated that if the shower suddenly would turn off or on without them expecting it, they would feel uneasy and irritated. A few users expressed that scheduling their shower times could perhaps help them taking shorter showers, but they were afraid that they would not have the same time to enjoy the experience.

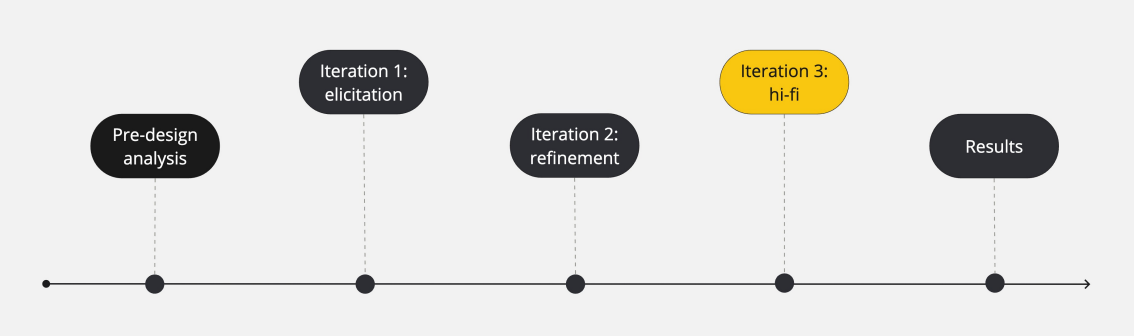

Figure 3.22: Showing what part of the design process is presented in this section.

3.4 Iteration 3: Hi-fi Prototyping

As Blocks proved to be the superior prototype during testing, it was selected for further development. This iteration entailed the development of a hi-fi prototype, which was then compared to the routine creation in My Water by user testing.

3.4.1 Design of Prototype

A hi-fi prototype was written in TypeScript using the React Native framework. The prototype was modeled after the lo-fi prototype of Blocks, with a few alterations.

Visually, the hi-fi prototype was highly reminiscent of the lo-fi version. One noticeable change was the timeline – it was now limited to 11 minutes, as can be seen in Figure 3.23. Another conspicuous change was the decision to base block color on temperature, as had been considered during the previous iteration, but settled on as infeasible to implement effectively in a lo-fi prototype. This was believed to facilitate distinction between blocks and make routines easier to look over.

In Figure 3.24, a relatively cold, blue block has been added to the routine. On a regular-sized smartphone screen, having a longer timeline would make it difficult to distinguish between minute lines. Furthermore, limiting shower duration was believed to also limit water consumption, which would be in line with the goals of Orbital and the UN.

Pressing any value field of a block would show a menu for adjusting any of the values of the block, as was the case in the lo-fi prototype, as displayed in Figure 3.25. However, in the hi-fi prototype, the menu was displayed as a pop-up window, instead of the user being directed to a different view, as this had been the subject of skepticism during lo-fi testing. Moreover, the continual view switching in My Water was considered cumbersome during testing in the previous iterations.

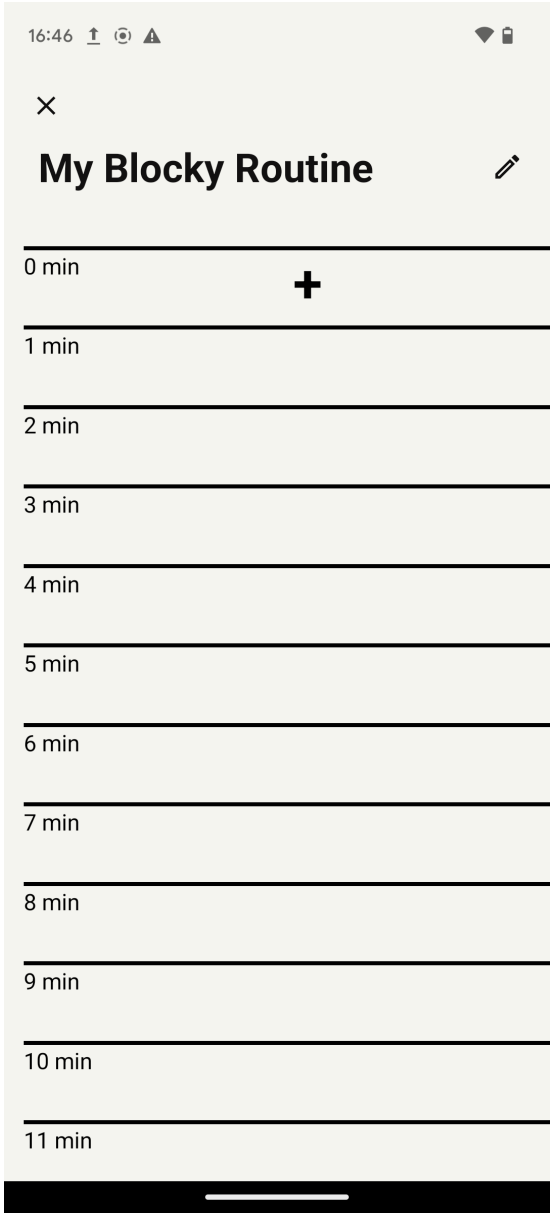

Figure 3.23: An empty shower routine in the Blocks.

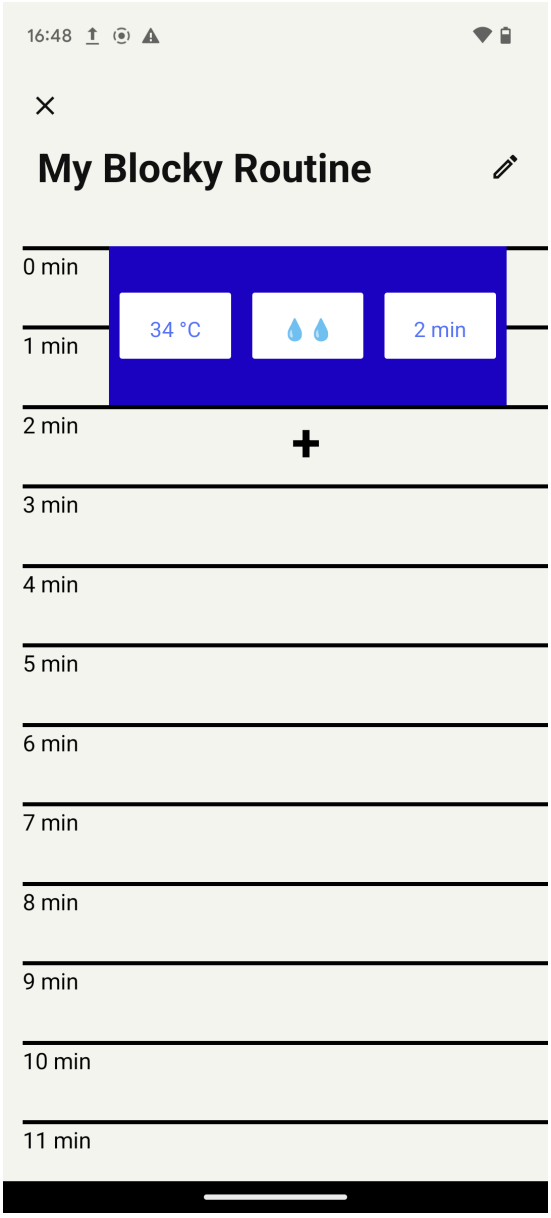

Figure 3.24: A routine with a single instruction block in Blocks.

The decision was made to substitute liters per minute by water droplets to represent flow. Test participants had questioned liters per minute as a unit ever since the My Water tests of Iteration 0, and often expressed an inability to imagine what a given number of liters per minute of water flow would be like once showering. As many participants were entirely indifferent being able to adjust water flow, water flow was limited to three levels in the hi-fi prototype, represented by the number of droplets.

Importantly, water flow could no longer be set to zero to create a pause. This was partially due to participants questioning the previous approach, and partially to simplify development of the prototype. Instead, pauses were now represented by white space in the timeline, as seen in Figure 3.26, and could be added simply by moving blocks around. Blocks could be moved around by dragging them, but would stick to the nearest minute line once

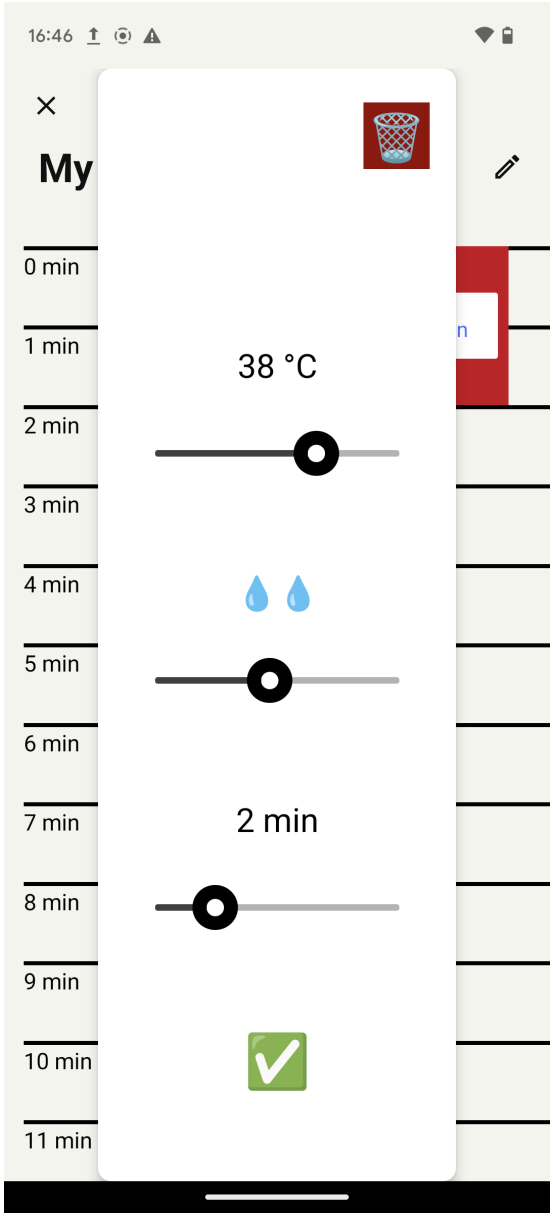

Figure 3.25: Block adjustment pop-up modal in Blocks.

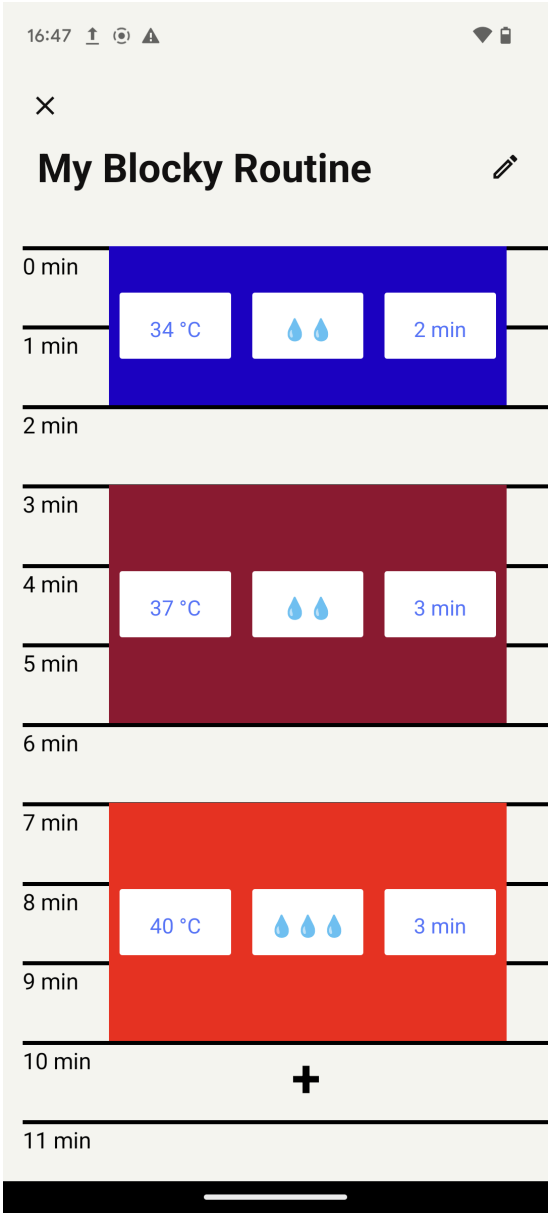

Figure 3.26: Example of a finished shower routine in Blocks.

released. Unrestricted vertical block movement was considered, but ultimately deemed as adding complexity without practical gain, as most shower sessions would not require such specificity.

When pressing the plus symbol, a new block with default settings would be added to the timeline, unlike in the lo-fi version where the user could customize the new block before creating it. This decision was mainly made to simplify programming, and seemed reasonable to make as the decision was considered fairly inconsequential in regard to the overall usability of the app.

The size of existing blocks could no longer be adjusted by dragging at the ends of the blocks. This functionality was omitted to simplify programming and because of a lack of usage by test participants in previous iterations.

3.4.2 Testing

Like in previous iterations, a number of user tests were carried out to evaluate the usability of the prototype. This time, Blocks was compared to the original routine creation functionality in My Water.

Test Structure

Test participants who had not partaken in previous tests were given a terse background of the project. The participant was asked to state their age, gender, and occupation. They were given a brief overview of the test structure and instructed to Think Aloud (see section 2.2.6). They were then presented with a Google Pixel smartphone with which to create routines in My Water and Blocks. Half of the participants started with My Water, and half with Blocks. Either way, they were instructed to recreate the same routine:

- Shower in 34°C with low water flow for three minutes.
- Turn the water off for two minutes.
- Shower in 40°C with high water flow for four minutes.

While the routine was being created by the participant, notes were taken of their approach to solve the task and what they said while doing so. Once they considered the routine completed, it was noted whether they had recreated the given routine successfully. This time, the criteria for successful recreation was less lenient; anything that would result in unexpected behavior while showering would result in failure. Blocks had to be placed in the right order, with some leeway for My Water, where sometimes different command orders could yield the same result. Values had to be exact, with the one exception being flow values in My Water, which had to be reasonable.

Like in previous tests, if the routine created had the same structure as the given routine and did not contain any values that would make the shower session be perceived as significantly different to what was expected, it was considered a success.

The participant was then asked to edit their routine and transform it into a different one:

- Shower in 40°C with medium water flow for two minutes.
- Turn the water off for one minute.
- Shower in 37°C with medium water flow for three minutes.
- Turn the water off for one minute.
- Shower in 33°C with medium water flow for two minutes.

Once again, it was noted whether the participant succeeded in recreating the given routine. When finished editing, the participant was prompted to fill in a SUS questionnaire to rate their experience with the app. The entire procedure was then repeated with the other prototype.

Finally, the participant was asked to answer the following questions:

- Which prototype did you prefer to use? Why?
- Would you have used any of the following features if they existed in the interface?
  - Standard or example routines
  - Suggested routines based on your showering data
  - Routines created by friends or celebrities
  - Water jet control
  - Music integration
  - Lighting integration
  - Voiceovers reading news, weather, or daily schedules
- Can you suggest any other features to add to the interface?

Test Participants

There were 21 test participants in total, of which 10 were women and 11 were men. The test participants were between 20 and 65 years old and had different professional backgrounds. Nine of the 21 participants did not have any significant programming experience, while the remaining 12 did. Two participants had also participated in tests for the first iteration, four participants had participated in tests for the second iteration, and two participants had participated in all previous tests. Participants were recruited through message apps or in person.

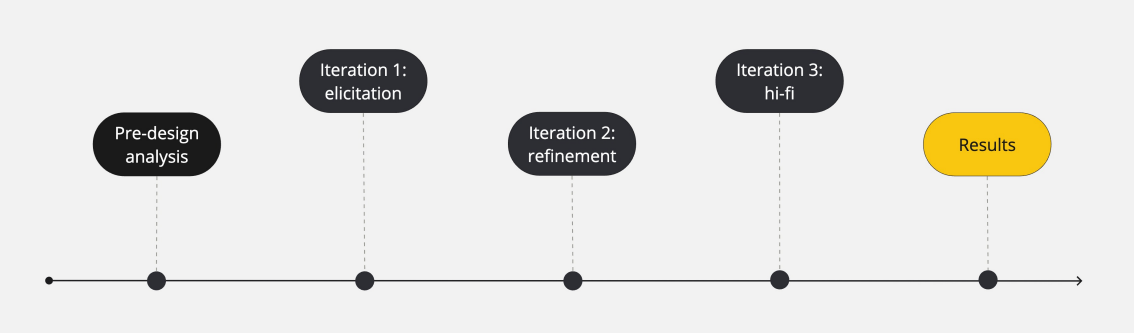

Figure 3.27: Showing what part of the design process is presented in this section.

3.4.3 Results and Analysis

Complaints in previous tests of My Water and its lo-fi prototpye version were reiterated. Participants had difficulty understanding the fundamentals of commands and command interactions, they often did not understand the difference between "Wait" and "Pause", and they found the interface cumbersome to use due to the numerous button presses required.

Most failures in solving the task stemmed from a lack of understanding of fundamentals, not adding "Shower on" commands after "Pause" commands, incorrect flow values, and failing to correctly change values due to loss of overview in the command list. Several participants failed the task due to incorrectly assuming that several values were saved for each command, often ending up with a list of only "wait" values in their routine.

As before, participants without programming experience performed significantly worse using My Water. Conversely, they did well using Blocks.

For most participants, the biggest obstacle when using Blocks was figuring out how to add pauses. Even this was sometimes trivial, as some participants immediately tried dragging blocks around. Other times, discovering this feature took a bit longer, and a number of other approaches were attempted first. Not seldom did participants try reducing water flow to zero when editing a block – especially participants that had tested during the previous iteration, as this had been the main approach then. Once dragging was discovered, however, participants usually correctly assumed that the empty spaces left between blocks were pauses in water flow. In one instance did a participant add an additional block for the pause as a placeholder to be removed when all "shower on" blocks had been added. Participants expressed a desire for something indicating the ability to drag blocks.

Before pressing the plus symbol, many participants tried pressing the timeline around the time stamp where they wanted the block, and expressed disappointment when nothing happened.

Success Rate

In figure 3.28 the results of successful tasks during Iteration 3 testing can be seen. For both prototypes there were two tasks: creation of a routine from a blank routine page, and then editing the existing routine (from the first task) to a new routine (as detailed in section 3.4.1). A task was deemed completed (and successful) if the test participant managed to recreate

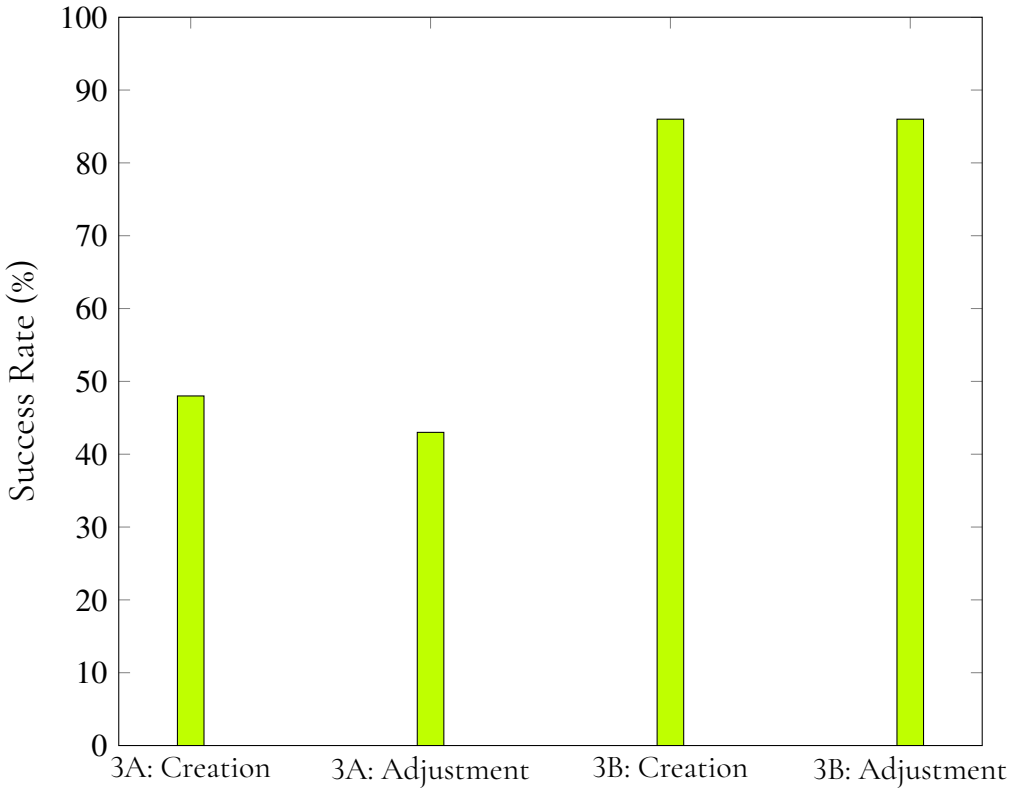

Figure 3.28: Success rates of My Water (3A) and Blocks (3B) in the user tests in Iteration 3.

the routine *entirely* (i.e. if the resulting shower experience would match that of the routine specification). In any other case, the task was deemed a failure.

Interview results regarding additional features

After testing both prototypes in the third iteration, participants were asked to answer yes/no on whether they would use certain features in their shower creation routine. If they felt strongly about something, they were encouraged to explain their reasoning. Table 3.3 shows the results from those interviews.

Table 3.3: Showing the estimated use of features as answered by participants during the hi-fi iteration.

Feature	Percentage that would use
Standard or example routines	53 %
Suggested routines based on your showering data	37 %
Routines created by friends or celebrities	10 %
Water jet control	84 %
Music integration	71 %
Lighting integration	48 %
Voiceovers reading news, weather, or daily schedules	10 %

Additional features suggested included:

- Dispenser of shampoo/conditioner
- "Shower occupied" sensors (i.e. for knowing when spouse is in shower)
- Other ways of progressing through the routine than time segmentation
- Shower cleaning and sewer clearage, or notifications of when to perform those tasks manually
- Scents, oils or perfume dispensing
- Radio

SUS Results

After each prototype test during the third iteration testing, participants were asked to fill in a SUS survey. Table 3.4 and Figure 3.29 show the results from these surveys.

Table 3.4: The results from the SUS surveys participants filled in immediately after testing prototypes 3A and 3B.

Participant nr	MyWater SUS score	Blocks SUS score
P 1	35	77.5
P 2	32.5	90
P 3	52.5	95
P 4	12.5	50
P 5	42.5	70
P 6	10	57.5
P 7	32.5	75
P 8	75	92.5
P 9	47.5	95
P 10	55	80
P 11	25	60
P 12	42.5	90
P 13	90	95
P 14	50	82.5
P 15	30	87.5
P 16	47.5	85
P 17	40	62.5
P 18	75	75
P 19	70	72.5
P 20	22.5	52.5
P 21	72.5	100
Average	**45.71**	**78.33**

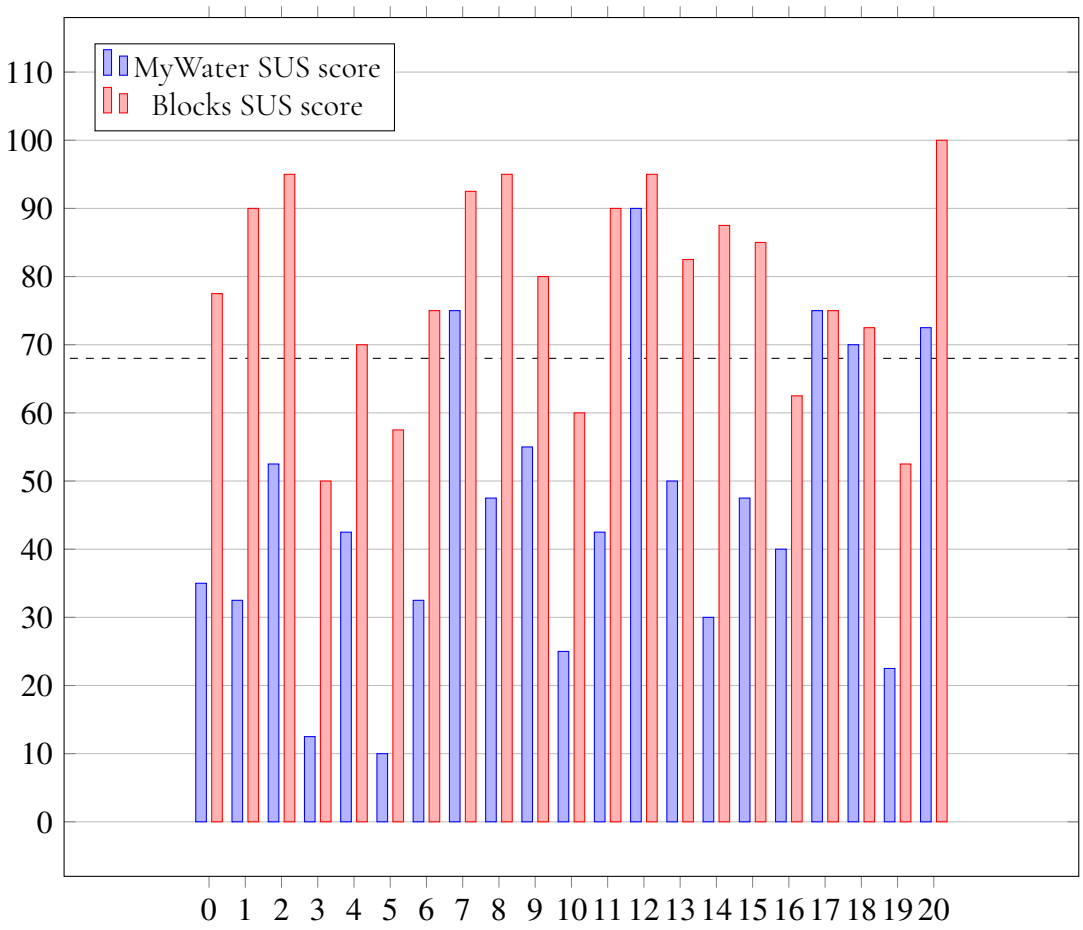

Figure 3.29: SUS scores from third iteration testing.

Chapter 4
Discussion

This chapter discusses the successes and failures of the design process as well as the final results of the project. The findings in regard to the research questions are presented as well as suggestions for future research on the subject.

4.1 General Process

In order to ensure that the final design of our app would be well received with the intended users of the shower creation routine function, a user-centered design process was chosen to guide the development. By constantly engaging with users throughout the design process, their thoughts, experiences and restrictions on the interface became clear and we were able to acknowledge their demands and expectations.

Overall, the project structure was satisfactory. The initial tests and interviews in the pre-design testing were a solid foundation on which the rest of the project could be based. The ample time spent on lo-fi prototyping allowed for a variety of designs to be explored and resulted in great confidence in Blocks as a concept. Conversely, while the hi-fi prototype outperformed My Water, the prototype had flaws and was the subject of some complaints during testing. Had more time been allocated toward hi-fi prototyping, perhaps by the addition of a fourth iteration, the final prototype may have become more refined and performed even better.

While a significant periods of time were dedicated to lo-fi prototyping, the different prototypes did not always receive equal amounts of time or equal amounts of effort. This resulted in some prototypes being of lower quality than others when user tested. Especially the more graphical prototypes, for which the range of possible input interactions was wider, tended to suffer due to insufficient preparation. The low performance of these prototypes did not necessarily reflect on the quality of the concepts on which the prototypes were based; it is possible that some design solutions were not properly explored and could have made for solid interfaces had these designs been given more time.

4.2 Results

As in every process involving user testing, more tests would produce a stronger indication of the result. For our iterations, we managed to hold 10, 8 and 21 user tests, respectively. Additionally, one pilot test was held for each iteration. Since the first iteration, the design origin point of prototype 1C: CalendarBlocks proved to be the preferred design of all designs among users. It strongly inspired the design of prototype 2A: Blocks that became the favorite of all testers in the second iteration, and was thus chosen as the entry point for designing the hi-fi-prototype in iteration 3. During the development process, users were presented with diverse designs to encourage exploration of the possibilities of the novel functionality. In the end, it became clear that a design benefiting from a clear conceptual model of the users (the calendar/school schedule) provided a more preferred interaction than one trying to provide a new, perhaps fun way of interaction. With regard to using a shower, users seemed to prefer a familiar concept of design, rather than venturing out into the unknown and inventing new ways of interaction.

Showering seems to fill one of two purposes for users: providing a time for relaxation, or providing a means to get clean effectively. During testing, some users expressed disappointment of features intending to shorten och control their showering experiences (perhaps shortening a pleasant shower by turning the water off at the most relaxing moment), while others expressed disappointment over having to many options related to comfort (being able to control flow values and exact temperatures). Throughout this design process, iterations have been made to design for a target group with the same goals, but in reality users might not experience showering in such a homogeneous way.

4.2.1 Result Validity

Limitations of the project may have jeopardized the validity of the final results. Test participants were a concern throughout the project. Few participants could be considered potential end users at the time of testing, as they often lacked the financial means required to purchase the luxurious Orbital Shower. Moreover, albeit varying between iterations, diversity in age and occupation among participants was often lacking. There was also a significant overlap in test participants between iterations.

There was inconsistency in regard to prototype quality. In the case of the lo-fi prototypes, the performance of some prototypes, especially graph-based ones, may have suffered due to poor preparation. These prototypes often required improvisation during testing, as no response had been determined for certain interactions beforehand.

During hi-fi prototyping, a number of features incorporated in the lo-fi version were omitted to facilitate development. Several of these were thought of as unnecessary, as they were targets for repeated criticism in previous user tests. During the hi-fi tests, however, their absence proved detrimental, especially to returning test participants. For example, creating pauses by selecting a block and reducing its water flow to the minimum was often considered an unconventional approach. During hi-fi tests, however, that was the default approach for multiple participants, returning and new alike. When the prototype failed to respond, participants were disappointed and sometimes bewildered as they had trouble conceiving of their next approach.

It seems wise to implement a plurality of options for users to elicit the desired response from the system — perhaps simply because different users interact with systems in different ways.

4.3 Research Questions

RQ1: How can the shower experience be improved by creation of custom shower routines?

While not appreciated by all users, these aspects of custom shower routines may enhance the shower experience:

- The ability of being able to schedule some time-limit to avoid showering for too long.
- The ability to limit their water consumption.
- Making showers more enjoyable by adding additional features.
- Making showering more accessible to users who might have difficulties showering in a traditional shower.

RQ2: What design choices make for a quality user experience in regard to custom shower routine creation?

We have shown that by creating a design based on existing user conceptual models, the design will be well received by users. Additionally, such a design provides successful results with regard to users achieving desired scheduling of a shower routine. We have also shown that using constraints to limit options when creating routines promotes usability. Users express appreciation of being able to view the entire routine at once, and express dislike toward frequently having to switch views.

RQ3: What functionality do users prioritize when creating custom shower routines?

Users seem to mainly be interested in adjusting temperature and water flow in terms of relative values, as they find it hard to visualize the effects of changes in units, e.g. in degrees or liters per minute. They do however not seem content with being able to choose between a smaller set of relative values, but rather prefer a larger range of options — even when they only are interested in using a small part of said range.

Users are interested in adding certain novel functions to their shower experience. The option to control the water jets is highly sought after. Users also seem interested in having standard and example routines, but are mostly against the collection of data to suggest personalized shower experiences. While users seem divided on the importance of music and light control, there is some interest in combining them and thereby create an experience. Finally, users seem interested in being provided with some information of for how long they have been in the shower, alternatively how long time they have remaining in their routine.

4.4 Future Work

The results of the user tests in Iteration 3 could serve as a basis for further improvements to Blocks:

- A signifier for the affordance of dragging blocks
- Reducing flow to zero as an option for creating pauses
- The option of adding blocks at specific time stamps by pressing the time line
- Providing access to detailed flow values
- A guide to how different temperature and flow values are perceived once showering

Furthermore, we encourage further research in regard to the following:

- Further testing among a broader base of the target groups.
- Further testing among users outside of target groups (to discover new potential for the application of creating shower routines). Suggested groups includes elderly, children, disabled, hospitals and countries where water is a scarce resource.
- Experimenting with different ways of triggering progress through the routines.
- Experimenting with implementing novel functionality into the shower experience (e.g. music, lighting) and performing user tests with those functionalities.

Chapter 5
Conclusion

There is skepticism toward shower routines as a concept. However, this could be alleviated by the addition of features such as standard routines, control over the type of water jets, and music integration coupled with lighting customization. The advantages of shower routines are the limit on water consumption, the guarantee that shower sessions do not last longer than planned, and the increased accessibility. When implementing a shower routine creation feature, a block-based interface reminiscent of calendar apps can be an effective design, as it utilizes familiar concepts for routine creation and provides a clear overview of the routine both during and after creation.

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