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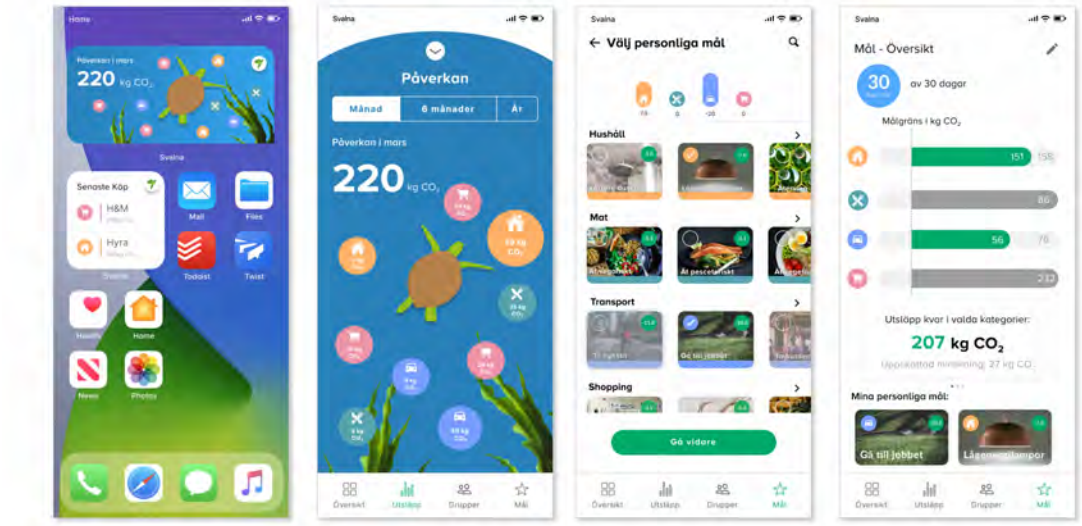

Designing for Long-Term Use of Carbon Calculators

Exploring Design Solutions for Carbon Footprint Applications to Support Sustainable Behaviors

Master's Thesis in Computer Science and Engineering

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Gothenburg, Sweden 2022

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Cover: A selected set of frames from the prototype concepts made for supporting long-term use in carbon calculators.

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Abstract

There exists a range of carbon footprint calculator applications on the market aiming to provide estimates of individuals' impact on the environment. These calculators can be an excellent tool for informing and inspiring sustainable lifestyles. However, research has shown that the impact carbon footprint calculators can have is limited as long as they are not used over an extended time. This thesis explores design solutions to inspire long-term use and provides recommendations of important aspects to consider when designing carbon calculators. Specifically, the thesis has used the Svalna carbon footprint calculator application to produced concepts and recommendations for general carbon footprint calculators.

In order to achieve this, an iterative *Design Thinking* process and *Research Through Design* were used. The process involved researching relevant theories and topics, involving potential users, designing and testing solutions, and using this knowledge to formulate a set of recommendations. The results consist of two Figma prototypes showcasing different concepts and a list of ten recommendations explaining important aspects to consider when designing for the long-term use of carbon calculators. These results can serve as a basis for future designers of carbon calculators, but to guarantee that the concepts would work long-term, more extensive long-term testing would have to be performed.

Keywords: User experience, carbon calculator, pro-environmental behavior, sustainability, long-term use.

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Alma Eriksson & Hanna Jacobsson, Gothenburg, June 2022

Contents

List of Figures **xiii**

1 Introduction **1**
1.1 Aim . . . 2
1.1.1 Research Question . . . 2
1.2 Delimitations . . . 2
1.3 Stakeholders . . . 3
1.4 Ethical Issues . . . 3
1.4.1 Participants Rights . . . 3
1.4.2 Surveillance Economy . . . 3
1.4.3 Awareness of Users . . . 4
1.4.4 Filter Bubbles . . . 4

2 Background and Related Work **5**
2.1 Carbon Calculators . . . 5
2.1.1 Effectiveness of Carbon Calculators . . . 6
2.1.2 Research Site . . . 6
2.2 Related Work . . . 7

3 Theory **9**
3.1 Pro-Environmental Behaviors . . . 9
3.1.1 Pro-Environmental Behaviors and Emotions . . . 10
3.2 Temporal Activity and Slow Interaction . . . 10
3.3 Long-Term Aspects Regarding Daily Activities . . . 11
3.3.1 Slow Interactions within Slow Technology and Design . . . 11
3.3.2 Daily Routines and Habits . . . 12
3.4 Long-Term Aspects Regarding the Climate . . . 13
3.5 Approaches for Motivating Long-Term Use . . . 13
3.5.1 Intrinsic and Extrinsic Motivation . . . 14
3.5.2 Notifications for Long-Term Use . . . 14
3.5.3 Gamification for Long-Term Use . . . 15

4 Methodology **17**
4.1 Research Through Design . . . 17
4.2 Design Thinking . . . 18
4.2.1 3 I Model . . . 18
4.2.2 Double Diamond Model . . . 19

4.3 The Hasso-Plattner (d.school) Design Thinking Model 19
4.3.1 Empathize Phase 20
4.3.2 Define Phase 20
4.3.3 Ideate Phase 20
4.3.4 Prototype Phase 20
4.3.5 Test Phase 21
4.4 Methods for Data Collection 21
4.4.1 Interviews 21
4.4.2 Literature Study 21
4.4.3 Questionnaire 22
4.5 Methods for Data Analysis 22
4.5.1 Affinity Diagramming 22
4.6 Methods for Ideation 22
4.6.1 Brainstorming 22
4.6.1.1 Brainwriting 23
4.6.1.2 Starbursting 23
4.6.2 Design Workshops 23
4.6.3 Mind Mapping 24
4.6.4 Personas 24
4.6.5 Storyboard 24
4.7 Methods for Prototyping 25
4.8 Methods for Evaluation 25
4.8.1 Concept Testing 25
4.8.2 Usability Testing 25

5 Planning **27**
5.1 Report Writing, Design Process and Presentation 27
5.2 Research and Collection of Data 28
5.3 Concepts Development and Testing 28

6 Design Process **29**
6.1 Literature Study 29
6.2 Empathizing with the Users 30
6.2.1 Questionnaire 30
6.2.2 Interviews 30
6.3 Ideation of the Concepts 31
6.3.1 Workshops with Students and Svalna AB 31
6.3.2 Brainstorming Ideas 33
6.3.3 Answering Questions Using Starbursting 33
6.3.4 Sketching the Concepts 33
6.3.5 Contextualizing the Concepts by Storyboarding 33
6.4 Low-Fidelity Prototyping and Testing 34
6.4.1 Wireframing 34
6.4.2 Testing of the Wireframes 35
6.4.3 Paper Prototypes 35
6.4.4 Testing of Paper Prototypes 36
6.5 High-Fidelity Prototyping and Testing 36

6.5.1 Mockups of Concepts . . . 36
6.5.2 Feedback on the Concept Mockups . . . 37
6.5.3 First Iteration High-Fidelity Prototype . . . 37
6.5.4 User Test of First High-Fidelity Prototype . . . 38
6.5.5 Final Iteration High-Fidelity Prototype . . . 39
6.5.6 User Test of Final High-Fidelity Prototype . . . 39

7 Results **41**
7.1 Empathizing with the Users . . . 41
7.1.1 Questionnaire . . . 41
7.1.2 Interview . . . 43
7.2 Ideation of Concepts . . . 44
7.2.1 Workshops . . . 44
7.2.1.1 Results from the Student Workshop . . . 45
7.2.1.2 Results from the Svalna Workshop . . . 46
7.2.2 Brainstorming . . . 47
7.2.3 Starbursting . . . 48
7.2.4 Sketching . . . 50
7.2.5 Storyboard . . . 50
7.3 Low-Fidelity Prototyping and Testing . . . 51
7.3.1 Wireframing . . . 51
7.3.2 Paper Prototype . . . 53
7.3.3 Test of Paper Prototype . . . 55
7.4 High-Fidelity Prototype and Testing . . . 56
7.4.1 Concept Mockups . . . 56
7.4.2 Testing of Concept Mockups . . . 58
7.4.3 First Iteration High-Fidelity Prototype . . . 59
7.4.4 User Test of First High-Fidelity Prototype . . . 60
7.4.5 Final Iteration High-Fidelity Prototype . . . 62
7.4.6 User Test of Final High-Fidelity Prototype . . . 63
7.5 Final Concepts and Designs . . . 65
7.5.1 Planning Concept . . . 65
7.5.2 Widget Concept . . . 67

8 Discussion **69**
8.1 The Final Results . . . 69
8.1.1 Approaches Explored for Long-Term Use . . . 69
8.1.2 Long-Term Use and the Final Concepts . . . 71
8.1.3 The Use of Animals in the Widget . . . 72
8.1.4 Information Displayed in the Concepts . . . 73
8.2 The Design Process . . . 73
8.2.1 The Phases and Methods . . . 73
8.2.2 The Methods of Testing . . . 74
8.3 Recommendations for Designing Long-Term Use in Carbon Calculators 75
8.4 Future Work . . . 77

9 Conclusion **79**

Bibliography **81**

A Appendix - Starbursting Questions and Answers **I**

B Appendix - Ideation Sketches **XI**
B.1 Sketches of Concepts XI
B.2 Concept Storyboards XV

List of Figures

4.1 Phases in the Hasso-Plattner (d.school) Design Thinking model . . . 19

5.1 The time plan for the project thesis displayed as a Gantt chart 27

6.1 Overview of the design process and the methods used in each phase. . 29
6.2 Examples of three different extreme character-cards. 32
6.3 Participants in each of the workshops brainstorming for the extreme character exercise. 32
6.4 Sketching on one of the ideas from the brainstorming. 34
6.5 The creation of the paper prototypes. 35
6.6 Screenshot from the recording of a participant interacting with the paper prototype. 36
6.7 Figma frames showing four different options for visualizing data in the emission overview. 37
6.8 The frames connected in Figma for the widget concept in the first high-fidelity prototype. 38
6.9 The added interaction connections for the widget concept in Figma. . 39
6.10 A participant performing the final test on a smartphone displaying the prototype. 40

7.1 The most common environmental actions taken according to users answering the questionnaire. 42
7.2 Feelings regarding the environment from users answering the questionnaire. 42
7.3 An example of the affinity diagram created from the interviews. . . . 44
7.4 An example from the brainwriting exercise showing how a calendar for environmental events could be implemented in the application. . . 46
7.5 Sketches from the extreme character exercise during the Svalna workshop. 47
7.6 A sketch from the rapid ideation session. 48
7.7 The mindmapping for the planning concept. 49
7.8 The questions that came from the Starbursting method. 49
7.9 An example of the sketches of the widget concept. 50
7.10 A storyboard showing a potential scenario for the widget concept. . . 51
7.11 The wireframes showing the two different options for the plugin concept. 52
7.12 The wireframes showing the flow for the planning concept. 52
7.13 The wireframes showing the different options for the widget concept. 53

7.14 The paper prototype showing the plugin giving suggestions more sustainable options to purchase. 54
7.15 The paper prototype showing the plugin giving sustainability information in the checkout of an online store. 54
7.16 The paper prototype showing the goals that can be selected by the user. 54
7.17 The paper prototype showing the sliders which the users can use to set goals. 54
7.18 The paper prototype showing the widget on the home screen of a smartphone. 55
7.19 The paper prototype showing the monthly overview of the turtles in the application. 55
7.20 A selection of the widget mockups created to test different options. . 57
7.21 A selection of the planning mockups created to test different options. 58
7.22 First high-fidelity prototype for the planning concept. 60
7.23 First high-fidelity prototype for the widget concept. 61
7.24 The changes made regarding the planning concept in the final iteration. 62
7.25 The changes made regarding the widget concept in the final iteration. 63
7.26 A participant performing the final user test on the prototypes. 65
7.27 A selection of key frames from the planning concept showing where users can select goals and learn more about them. 66
7.28 A selection key frames from the planning concept showing where users can select goals and learn more about them. 66
7.29 Frames from the widget concept at the beginning of the month. . . . 67
7.30 Frames from the prototype showing the widget concept later in the month. 68

B.1 Sketches showing screens from the planning concept. XI
B.2 Sketches showing screens from one version of the plugin concept. . . . XII
B.3 Sketches showing variations of widgets for the widget concept. XIII
B.4 More sketches showing widgets for the widget concepts. XIV
B.5 A storyboard showing one version of the widget concept. It shows a widget with emission data visualized and how Margot interacts with it. XV
B.6 A storyboard showing one version of the plugin concept. It shows Margot getting information on the emissions of her online purchases through a plugin. XVI
B.7 A storyboard showing one version of the plugin concept. It shows Margot receiving suggestions on more sustainable purchases when online shopping though a plugin. XVII
B.8 A storyboard showing the planning concept. It shows how Margot uses the planning concept in the application to lower her emissions. . XVIII

1

Introduction

The topic of climate change is widely discussed in today's society. Temperatures are increasing on earth, causing a threat to many physical and biological systems, which leads to earlier springs, floods, and longer dry seasons (Parry et al., 2007). The climate crisis has been in the public's awareness since the 1980s but has been an issue decades before. Climate change is a process that took a long time to evolve and is just as slow to reverse. Although it is an urgent problem, there is no quick solution to the climate crisis (Moser, 2010).

Technology has been seen as one of the leading solutions to climate change for a long time. The problem is being approached from multiple directions, with some people trying to make the already existing technology greener, such as electric vehicles and renewable energy. In contrast, others try to make people's behaviors more sustainable instead. Changing behaviors involves using technology in the areas of Human-Computer Interaction (HCI) and behavioral science (Stern, 2011).

One type of technology that is designed to change behaviors is carbon calculators. A carbon calculator is a tool designed to measure and give feedback on the carbon footprint of individuals (Biørn-Hansen et al., 2020). They are designed to take input about an individual's lifestyle and output information about their impact on greenhouse gas emissions. The results of studies looking at the effectiveness of carbon calculators are often mixed. Some studies have shown that they can lead to a reduction among the participants, whereas others see no actual effect on people's environmental behaviors (Andersson, 2020). There are also studies that show that there are ways to improve the effectiveness, such as personalized information, instant feedback, and long-term use of tools (Büchs et al., 2018).

This thesis has been created in collaboration with Svalna and their carbon footprint smartphone application. Currently, there is research on the long-term use of carbon calculators. Many studies look into the use patterns of carbon calculators and the effectiveness of calculators over a longer time. Svalna has also touched upon the topic in previous master theses and their research. Researchers mention that the lack of long-term use could be an obstacle to carbon calculators having a more significant impact on the climate (Barendregt et al., 2020). Although the problem itself is well known, we found a lack of research on exploring design solutions to the problem. This thesis attempts to contribute knowledge to fill this gap.

1.1 Aim

The thesis aims to find design solutions for long-term use in carbon calculators. Investigating different techniques to influence users to use the Svalna application over a more extended period provides insights into how Svalna can improve its design to support long-term use. More long-term use of the application is believed to have a more significant impact on the sustainable behaviors of users. The result consists of important aspects and recommendations to consider when designing for long-term use in carbon calculators. To accomplish the aim, *Research Through Design* was applied, further described in section 4.1. Furthermore, several interactive Figma prototypes were created during the design process and will be given to Svalna together with the essential aspects found. Moreover, another approach used was *Design Thinking*, further explained in section 4.2. It was used both as the primary approach and as a base for the iterative design process because it allows for creative thinking and a flexible design process.

1.1.1 Research Question

The project aims to answer the question:

" *What are important aspects to consider when designing interaction for a carbon calculator while considering long-term use for supporting and influencing users to a more sustainable lifestyle?* "

1.2 Delimitations

Delimitations mentioned here are relative to the design process as well as the results because of the effect they can have. The thesis is about long-term use, but the testing was conducted during a short time, around five weeks. We are assuming that the project, in the end, would fulfill requirements that can support that it works for long-term use. The test groups were also be small due to the limited time for handling the data collected from each participant, and iteration steps are prioritized over handling data from a larger participant group. The testing took place in Sweden, and the data received from Svalna is concerning the Swedish life standard and might not work for other countries.

Lastly, the function created for the Svalna application were not tested together with their platform because the product was only be created as a prototype in Figma. Figma does not have a function that includes an already designed application with their prototyping program. The project's purpose is to give information to Svalna on long-term use and not on how the function is fully supposed to be implemented into their product.

1.3 Stakeholders

The internal stakeholders of this project are Svalna and its employees. External stakeholders include the customers of the application, companies and organizations that work together with Svalna, and other external companies that might be affected by people's changes in consumption habits.

1.4 Ethical Issues

There are several ethical issues related to the project. Some are connected to the design process, whereas others are related to Svalna or the topic of climate change. The issues described in this section are *Participant Rights*, *Surveillance Economy*, *Awareness of Users*, and *Filter Bubbles*.

1.4.1 Participants Rights

The thesis project included user studies with participants to gain information and perform testing. The participants in these studies and testing were informed about their right to withdraw at any point. The participants were also informed about data handling and asked for consent for pictures.

The project's primary focus is to promote a sustainable lifestyle to users. Therefore, it is essential to prioritize this focus over stakeholder gain if the two clash. For example, suppose a concept would raise the carbon footprint but benefit specific stakeholders. Further exploration of this concept would not proceed as this goes against Svalna's vision and the project's primary focus.

1.4.2 Surveillance Economy

Surveillance economy describes a market-driven process where personal data is captured from users and sold for profit. This process relies on mass surveillance of the internet and is often conducted by free online services such as Google and Facebook. Surveillance economy is often described by the aphorism "if you are not paying, you are the product" (Clarke, 2019). Zuboff (2015) describes the aim of the surveillance economy to be "to predict and modify human behavior as a means to produce revenue and market control" (p.75).

Clarke (2019) explains that there are some ways in which individuals gain from the digital surveillance economy with, for example, targeted ads. They can be seen as convenient, time-saving, make the user feel more understood by corporations, and create a personalized user experience. However, at the same time, there are several

problems with surveillance. It can manipulate users to consume more and lead to discrimination if algorithms are based on irrelevant or erroneous data. It is difficult to determine the reliability of the data collected, and a big part of the data is viewed as poor quality. Biased algorithms can have an effect in industries such as banking, insurance, and healthcare, where biased algorithms could have a severe effect on people's lives (Clarke, 2019).

As for this thesis project, it was important to keep the users' best in mind and not make any decisions with the data that could hurt or disrespect the users. The collected data of the users, such as information about their lives and their financial transaction data, was integral to the concept of Svalna in itself, and we therefore put focus on not collecting any unnecessary data and put user privacy over profit.

1.4.3 Awareness of Users

There is a discussion about the difference between achievements and freedoms that "achievement is concerned with what we manage to accomplish, and freedom with the real opportunity that we have to accomplish what we value." (M. Ryan, 2022, pp.4). M. Ryan (2022) gave an example of a case using a bicycle. A person that can use a bicycle can benefit from it while increasing one's freedom, a bicycle can be a little benefit for a person that is unable to use it. In the case of ethical aspect, this could be a problem if one has the goal to reach a milestone, but the strategy given by the application is not favoring certain users. This could be users that are unable to reach a set goal by the given strategy from the application because of money or disability. In this project, this meant being aware of that suggestions made to the users should be inclusive and provide options for different kinds of users.

1.4.4 Filter Bubbles

Filter bubbles is an ethical problem that can occur with using applications that contain information on topics or give advice on how to change behavior. Filter bubbles occur when individuals disconnect themselves from other places with sources of information outside of their bubble. M. Ryan (2022) mention that application that provides this kind of information should show where they have found it and provide a list with relative resources individuals can look up. This is to avoid inaccurate information if a glitch or an error in the application would occur. For example, Svalna could have an error on their application saying *flying is good for the climate*, then a person can fact-check that information through their recommended lists.

In this thesis project, filter bubbles can be prevented through giving the users further reading from reliable sources and encourage them learning more about climate change on their own. It also shows the importance of the information given to the users to be correct not to mislead users in their pursuit of a more sustainable lifestyle.

2

Background and Related Work

The following chapter covers the background of the thesis project. The chapter includes information on carbon calculators and their effectiveness, as well as our research site, Svalna, and their carbon footprint calculator application. These sections are followed by related work describing research related to ours.

2.1 Carbon Calculators

A carbon calculator is a technology designed to measure and give feedback on the carbon footprint of individuals (Biørn-Hansen et al., 2020). They are designed to take input about an individual's lifestyle and give output on the impact they have in terms of greenhouse gas emissions. Carbon calculators have been developed for several purposes such as research, business, and non-profit and therefore have different functionality and aim (Andersson, 2020). Some calculators have more educational goals and are therefore trying to teach the users how their lifestyle choices impact their carbon emissions, such as the WWF Footprint Calculator (www.footprint.wwf.org.uk) and the carbon footprint calculator of the United Nations (www.offset.climateneutralnow.org). Other calculators encourage the user to offset their emissions by investing in different carbon compensation projects, such as MyClimate foundation (www.myclimate.org) and ClimateCare (www.climatecare.org) (Andersson, 2020).

Different calculators use different methods of calculating emissions. Some exclusively use the information provided by the user, such as housing, energy use, travel, and food, whereas others collect their data from multiple sources. Some calculators only look at the CO_2 emissions, whereas others also look at other greenhouse gasses. Newer carbon calculators often have more features such as comparisons to averages, tips, pledges, and options for carbon offsetting (Barendregt et al., 2020). Carbon calculators are often designed for living conditions in specific countries such as Tomorrow (www.tmrow.com) in Denmark, Ducky (www.ducky.eco) in Norway, and Deedster (www.deedster.com) in Sweden (Andersson, 2020).

2.1.1 Effectiveness of Carbon Calculators

Studies investigating the effectiveness of carbon calculators are often mixed results. Some of them have shown that they can lead to a reduction among the participants, whereas others see no actual effect on people's environmental behaviors (Barendregt et al., 2020). Researchers mention the benefits of carbon calculators as showing a clear connection between lifestyle choices and emissions and can therefore be a good teaching tool. Carbon calculators can also serve as inspiration and motivation to those who are already interested in the topic of climate change. Lastly, they can encourage reflection and discussions about the topic of how lifestyle and climate impact are related (Gram-Hanssen & Christensen, 2012).

There are some disadvantages to carbon calculators. According to Biørn-Hansen et al. (2020), the basic idea of a carbon calculator " (...) rests heavily on the assumption that if the user is provided with the right kind of decision support they will act more environmentally friendly" (Biørn-Hansen et al., 2020, pp.11). Researchers have been critical of this assumption since there is a lack of empirical evidence showing a strong relationship between awareness and willingness to act environmentally. In addition, most people using carbon calculators seem to be already interested in the environment, meaning that the calculators often do not reach the people contributing with the highest emissions (Gram-Hanssen & Christensen, 2012).

Another discussed issue regarding carbon calculators is if they place too much responsibility and blame on individuals rather than society. For example, when evaluating a Danish carbon calculator called *Map My Climate* from 2009, many questions regarding this were brought up. Participants felt limited in what they could do since they either had a landlord making decisions about things like heating or had lived in rural areas and felt like they needed to use a car to get around. Several participants thought that they would be more inclined to make changes for the environment if society as a whole, the government, the municipalities, and companies did more (Gram-Hanssen & Christensen, 2012).

Some of the biggest challenges for carbon calculators are making the calculations trustworthy and inspiring long-term use. Studies show that people rarely use the calculators more than once, which means it is difficult to make an actual impact on the user's lifestyle (Biørn-Hansen et al., 2020). In addition, users tend to be critical of the results of the calculators, possibly because of denial of how much environmental impact their lifestyle has. Another reason could be the lack of functionality to calculate the individual's climate impact if they live together with other people (Barendregt et al., 2020).

2.1.2 Research Site

Svalna is a research-based green-tech company based in Gothenburg, Sweden. They have developed a carbon calculator application that uses a hybrid approach to more accurately calculate users' carbon footprints and give more personalized advice to

make the users lower their emissions. The application does this through data from financial transactions, official registers of government agencies, and information entered by users. Svalna has a goal to encourage people to make a difference through a service that helps people measure and reduce their emissions while making the topic of climate graspable for experts as well as ordinary people (Svalna, 2022). One of Svalna's main problems is to keep users in the application long-term. Long-term use could hopefully lead the application to have more impact on users' lives and, in the long run, be more effective towards climate change (Barendregt et al., 2020). A way of accomplishing this would be to make using the application a part of people's habits and lifestyles.

2.2 Related Work

Many applications have been trying to tackle climate change and create solutions for sustainable living. An important topic to consider when looking at sustainability and applications is efficiency. For example, Brauer et al. (2016) researched how existing mobile applications contribute to environmental sustainability. Similarly, D'Arco and Marino (2022) have also investigated the moderating effect of sustainability applications on environmental citizenship behavior.

A common way of achieving sustainability is to provide sustainability-related information to the user to change behavior, such as in the electricity sector. Weiss et al. (2012) used an approach to allow the user to monitor and control domestic energy consumption via a smartphone application. In addition, the same information approach has also been explored within the transportation section. For example, Tulusan et al. (2012) and Froehlich et al. (2009) have used smartphones to display environmental data to the user to influence sustainable behavior.

Another common technique used by applications to promote sustainability is gamification. Douglas and Brauer (2021) provide a brief overview of gamification in the context of sustainability. They classify applications into different categories and give plenty of examples of board games, digital games, and applications meant to tackle the topic of sustainability in different ways.

As for the topic of long-term use and applications, several papers have been looking into how the user experience of applications evolves over a long-term period. Papers written on long-term use and applications include Li et al. (2020), which looked at applications through a macro-level, i.e., application-category, and micro-level, i.e., individual app. They discovered that they could observe that application-category usage assimilates while individual application usage diversifies over time and that there are different phases of application use. Kujala et al. (2011) also looked into the phases of long-term user experiences and created a UX curve model, which explains user experiences over time.

Research has also been done on carbon calculators and long-term use. Papers such

as the ones written by Büchs et al. (2018) and by Gram-Hanssen and Christensen (2012), look into the use patterns of carbon calculators and the effectiveness of calculators over a longer time. Salo et al. (2019) further discussed the issue when looking at different Nordic carbon calculators, in which it was pointed out that retaining users was a big challenge.

As for Svalna in specific, research made in conjunction with them has touched on carbon calculators and long-term use many times. A previous thesis written in collaboration with Svalna by Biørn-Hansen (2019) investigated both the first-time and long-time experience for users in the Svalna application. A paper written about the users' experiences in the Svalna application Barendregt et al. (2020) mentions that the lack of long-term use could be an obstacle to the Svalna application having a more significant impact on creating sustainable habits for users. The challenge of retaining users long-term is also mentioned briefly in (Andersson, 2020).

3

Theory

This chapter will present theories relevant to the thesis, starting with introducing pro-environmental behaviors and how these are connected to emotions. After that, theories related to temporal activities and slow interaction will be presented. These theories are followed by two sections presenting long-term use in daily activities and the climate. Finally, the chapter ends with approaches to achieve long-term use concerning the climate.

3.1 Pro-Environmental Behaviors

The attitude towards the environmental movement in public can be grouped into various segments. This grouping can help understand the general opinion surrounding the environment and find patterns in each of these subgroups and their engagement in pro-environmental behaviors. Theodori and Luloff (2002) grouped people into five pro-environmental behavior categories;

- The *activist* is an individual who is intensely concerned about and personally active on behalf of the environment.
- The *attentive public*, who are individuals informed about and interested in environmental issues that occasionally support environmental causes.
- The *sympathetic public*, is not very attentive toward environmental issues but expresses support for the cause.
- The *neutrals* have little interest in environmental issues and tend to have no opinions on the topic.
- The *opponents*, as opposed to the goals of the environmental movement to some degree and holds opinions that can be characterized as 'anti-environmental".

The model also included controlling for age, education, income, and political ideology to get a better perspective of the groups. The result of the research showed that age failed to give any statistical significance. Education showed to be significant

to pro-environmental behavior, especially among highly educated people, who were more likely to contribute money to environmental causes than people with lower or non-education. They were the people who would contact government agencies related to environmental issues, read and watch areas surrounding the environmental aspect. They were also more likely to vote for a political candidate because of their political and environmental views. Males showed to be significantly more likely than females to stop buying products because of the environmental impact they cause, while females were more likely to attend environmental meetings. People with higher income were more likely to contribute money or time to an environmental cause than people with lower income and are more likely to vote for a political candidate because of political position regarding environmental questions. These commonly belong to the liberal views, while people voting against them were typically conservative. Liberals were also the ones that were most likely to spend money on conservation efforts and magazines involving the environment (Theodori & Luloff, 2002).

3.1.1 Pro-Environmental Behaviors and Emotions

Studies have shown that positive and negative emotions could encourage engagement in the environment, such as feeling proud and guilty. People often feel pride when they have done something that could be viewed as moral and valued, while feeling guilty comes from immoral and inappropriate behaviors. Regarding the climate, people are more likely to feel guilty about the environment when their carbon footprint is larger than the average individual. There are also collective feelings of pride and guilt within groups, such as nationalities, which can impact a person's emotion of feeling pride or guilt depending on what other people do. Research on prosocial behavior has shown connections between a person's behavior and pride, meaning that pride often reinforces a behavior (Bissing-Olson et al., 2016, pp.145-146).

Other studies have shown that people can feel more desire to change their behavior and adapt to a more environmental-friendly lifestyle when the aspect of environmental guilt is used. Furthermore, environmental guilt has shown an association with pro-environmental behavior, which means that people are more willing to engage in eco-friendly behavior (Tam, 2019).

3.2 Temporal Activity and Slow Interaction

Time and how one can measure interaction as time is frequently discussed in HCI research. Ideas related to HCI and time have changed over the years, but Wiberg and Stolterman (2021) explains that *temporality* is one of the key dimensions surrounding the topic. Temporality can be defined as "the state of existing within time" (Odom, Lindley, et al., 2018, pp.384) or, put more simply, something that shapes our experience and what is around us. They explain that time is the medium where interaction between humans and computers happens, as it is where it begins, unfolds,

and resolves. Therefore, different experiences of time involving humans and computers can affect the outcome of the interaction with technology (Odom, Lindley, et al., 2018).

Others have theorized that temporality can be viewed as a *temporal activity* or a *slow interaction*. Temporal activity is the idea that interaction can be separated from the definition of time and that it is more about events, processes, and activities than the creation of things (Wiberg & Stolterman, 2021). Slow interaction in HCI refers to creating something part of a human's life for a longer period. It is a technology that" (...) expands its focus beyond creating tools to make people's lives more efficient." (Odom, Wakkary, et al., 2018, pp.1).Using something over a longer period, more known as long-term use is also a temporal aspect as it is a technology used over a longer time. There is a discussion around slow interaction being more supportive when it comes to social connections and long-term use in technology for everyday computational objects (Odom, Lindley, et al., 2018). Slow interaction can support the long-term use of technology objects because it allows reflection, exploration, development, and integration into our daily activities during a more extended period.

3.3 Long-Term Aspects Regarding Daily Activities

This section looks into the term of long-term regarding the subject of daily activities created by meaningful interactions, such as slow interaction and technology, and how our routines and habits are formed over time.

3.3.1 Slow Interactions within Slow Technology and Design

As mentioned in 3.2, slow interaction in HCI is to create something that is part of a human's life for a longer period of time (Odom, Wakkary, et al., 2018, pp.1). *Slow interaction* is part of the subjects of *Slow Technology* and *Slow Design* which are a part of the *Slow Movement*. Slow Movement advocates in slowing down the pace of life. (Grosse-Hering et al., 2013, pp.3432).

Humans are used to *Fast Technology* technology that is meant to be efficient in functionality with a well-defined task. Fast technology aims to limit the time it takes to do a task and further refers to making the users more efficient when working while making the product as fast and easy to use. We often want to design to limit the time it takes to; (i) learn how it works, (ii) understand why it works the way it works, (iii) apply it, (iv) see what it is, and (v) find out the consequences of using it. If not limited, the product can be viewed as having a bad design or being too complex (Hallnäs & Redström, 2001).

Slow Technology regarding the list (i-v) can describe fundamental and intentional slowness of learning and understanding, the presence of something. To make things more precise, the difference between Fast and Slow Technology is not in terms of time perception but rather a metaphoric distinction referring to awareness of time presence. Slow Technology should focus on the learning and understanding process while also giving people time to think and reflect. It should not be time-consuming but allow us to reflect on new activities. Technology considered slow focuses on expression and functionality rather than its objectives (Hallnäs & Redström, 2001).

Slow Design focus on ideas of well-being. It is a design philosophy that promotes and encourages individuals to take their time doing things right and at the right speed, which helps them understand and reflect on their actions. This approach could further help designers produce products that promote more meaningful interaction and appreciation to support product attachment. If the attachment and experience over a product one use can be increased, it will most likely lead to a lengthened lifecycle for that product. ”When a person becomes attached to an object, they are more likely to handle the objects with care, repair it when it breaks, and postpone its replacement for as long as possible” (Schifferstein & Zwartkruis-Pelgrim, 2008, pp.1). Three elements that can increase a product attachment for an individual are functions, symbolism, and material qualities—having Slow Design in mind when designing can make people slow down and make them think about what they are doing and why. As a result, people will most likely feel like they have control and, at the same time, feel more relaxed (Grosse-Hering et al., 2013).

3.3.2 Daily Routines and Habits

Human routines and habits are influenced by what is practical in the surrounding environment. A routine is often influenced by cultures and social groups that define what an ideal routine is or is supposed to be. Gallimore and Lopez (2002) describes that clocks and time are part of modern daily life and that" (...) living by the hour has become a habit for most citizens in complex societies." (Gallimore & Lopez, 2002, pp.71S). Humans live by the hour in many aspects that create our habits, such as family dinner always taking place during a certain time but can differ depending on the family. The time is not mandatory or required, but they are transparent and occur unnoticed within a family. This is what Gallimore and Lopez (2002) refers to as *cultural activities* - ”(...) families, mundane, often joint goal-directed task and interactions embedded in relative ubiquitous settings (...)” (Gallimore & Lopez, 2002, pp.71S). *Local ecologies* also affect our daily routines such as work and child care. For example, families desire to have a specific dinner time, but job schedules or other factors might interfere with that plan. Local ecologies reinforce the idea that individual behavior is shaped by our daily routines, further constrained and enabled by our surrounding ecology. The desired routine is not always possible to achieve. Social ecology supports daily routines but at the same time constrains daily life and makes changes difficult (Gallimore & Lopez, 2002).

3.4 Long-Term Aspects Regarding the Climate

Most people have heard about keeping the warming below 2^oC in temperature, which was agreed on and adopted in December 2015. This agreement further includes pursuing an effort to limit it even further to 1.5^oC (Vicedo-Cabrera et al., 2018). It is not the first time an agreement like the Paris one has been discussed and created. One big step toward a united goal for limited greenhouse gases happened in 1997 with the Kyoto agreement, which constructed a protocol to reduce emissions by 5%, which took effect in January 2005. It also mentioned the avoidance of warming up the climate by 1^oC to 2^oC. (Hasselmann et al., 2003).

These agreed-upon goals were set long-term, knowing that it could take years to change a country's infrastructure or behavior. Hopefully, it will benefit the climate and avoid major long-term climate change later on. Long-term within climate can go both ways - either we change and hopefully reach the climate goal, or we can ignore climate changes and deal with the consequences long-term. It is also important to note that this cannot be reached only using short-term policies but requires a broader spectrum. These agreements often focus on the most cost-effective technologies, such as wind energy, fuel switching from coal and oil to gas, and improving the transport sector. If implemented fully, it would halve the global greenhouse gases within two decades. The reality of this approach is that it might not be suitable or realistic for the developing world. Future emissions will come from the expanding populations of these countries, which might only use low-cost technology that has a limited capacity for sustainable global emission reduction. Therefore, affecting the long-term solution for reaching the near-zero emission can take longer than wanted.

Another mention is the long-term commitment government can implement to the investment of new cost-effective green technology. It is not sure that the effect of these technologies will achieve the wanted goal. Overall the long-term goal of climate change is to motivate businesses and individuals to change practices and behavior, such as investment, research, and education, that can be acceptable not only today but over a long time (Hasselmann et al., 2003).

3.5 Approaches for Motivating Long-Term Use

Motivation and long-term use go hand in hand - one might need to feel motivated to do a task for a more extended period, but it is not always that simple. So what can make individuals feel motivated, and what kinds of approaches can designers use to increase one's motivation regarding long-term use? This section will define motivation and further describe two approaches, notifications and gamification, for improving people's motivation and how they can remind people to perform tasks.

3.5.1 Intrinsic and Extrinsic Motivation

According to R. M. Ryan and Deci (2000) "(...) to be motivated means to *be moved* to do something" (R. M. Ryan & Deci, 2000, pp.54). Motivations are not the same for each individual as it varies depending on what motivates one and how much motivation a person has toward a task. This concept is called *orientation of motivation* which concerns "(...) the underlying attitude and goals that give and rise to action (...)" (R. M. Ryan & Deci, 2000, pp.54) meaning that it concerns the why of action. There are two distinct types of motivations based on the difference between reasons or goals that affect the willingness for action, and these are *intrinsic motivation* and *extrinsic motivation*. Intrinsic motivation is defined as "(...) the doing of an activity for its inherent satisfactions rather than for some separable consequence." (R. M. Ryan & Deci, 2000, pp.56). When a person is motivated, they are more likely to act for the fun rather than doing out of prods, pressure, or rewards. This approach focuses primarily on psychological needs such as the need for competence, autonomy, and relatedness. However, it also recognizes the need for satisfaction from engaging in what individuals see as interesting activities. Intrinsic motivation and its freedom to be motivated can become weaker. For example, a person can feel less motivated with each advancing grade in school, creating the need for extrinsic motivation. Extrinsic motivation is the motivation for completing a task that has been influenced by an external cause. For example, a student might only do homework because of the fear of parental sanctions, and they are then more motivated to do the work to avoid the sanction from their parents (R. M. Ryan & Deci, 2000).

3.5.2 Notifications for Long-Term Use

Notifications is an approach to motivate users by informing and reminding people to increase the use of applications. They can be challenging to design because they can sometimes be too interruptive for their users, and they lack choices for customization. *Disruptive notifications* is defined as being something that can be too irruptive that outweighs the benefit of the product. Smith et al. (2014), mention three approaches to address disruptive notifications. These approaches are *receiver scheduling*, delayed notifications received until a better moment comes along, *sender scheduling*, where the use of context on the phone to estimate which moments are best for sending notifications. Lastly, *mitigation*, where notifications are modified to make them as non-disruptive as possible, avoiding ringtones and light (Smith et al., 2014).

Research has shown challenges with creating non-disruptive notifications and overall smartphone interruptions. Most of the research performed is focused on the short term, meaning that some future work on handling notifications considering long-term use needs to be conducted (Smith et al., 2014). Other challenges have been to know what feedback users need and how often feedback should be presented for its users. Most studies found has been on daily registration of health or social

aspects. Our thesis will not necessarily include daily login but rather give some reminder of their lifestyle and the impact of their choices. It is still important to read and understand notifications on other occasions and what has worked or not. The following two paragraphs will be about two research about feedback or daily registration within an application and their founding.

Voida et al. (2015) created a research study about feedback and notifications, to answer the questions of what and when people need it. Their test involved steps taken and measures with a Fitbit, which divided participants into three groups with different amounts of feedback surrounding their Fitbit and steps. The groups were *full feedback*, meaning unlimited access to both the Fitbit website and the visual feedback on their Fitbit, *partial feedback*, access the Fitbit website once a day with all visual feedback displayed on the Fitbit, and *no feedback*, no feedback from either the website or the visual display on the Fitbit. The result showed the importance of feedback for keeping people motivated to reach the daily steps. The participants involved in the no-feedback group completed their daily steps in the first two weeks, it then got harder for them to feel motivated to reach their goal because they did not know how many steps they have taken. They also found that full feedback was necessary for the participants to keep track of their steps. The use of the website can be optional but it does not effect the overall motivation. The study overall showed the importance of feedback for motivating people to reach a goal and having the choice to regulate their feedback (Voida et al., 2015).

The topic of choice in notifications is mentioned in Bentley and Tollmar (2013) study about how notifications increase self-login for a wellness application. They described how easy it is for people to forget or lack the motivation to self-login to register things. Their solution was to use a simple status-bar reminder to increase people's self-login. One of the status bar functions is the possibility to set the desired time the participant would like to receive the notification. They also made the notification non-interrupting, that it would not either ring or vibrate, but a small icon would show up on the notification tray and then click to expand the information on the entry and be taken straight to the login. To set the desired time of the notification showed to be an important moment for the participants. They noticed that all of the participants had set different times, which also showed that participants had different schedules when it was suitable to log their daily food intake. Making them decide over a simple notification could give them more freedom and use the application more frequently (Bentley & Tollmar, 2013).

3.5.3 Gamification for Long-Term Use

Gamification is defined as "...a method that integrates game mechanics and game dynamics to non-game platforms" (Law et al., 2011, pp.349). It has been an approach for a while as a strategy to influence and motivate people. Using gamification inside applications is to engage users by completing specified activities. It is further used to build up user loyalty rather than fully have them commit to a long-term engagement. Few studies have shown that including gamification can help keep users

for a more long-lasting relationship with the application. However, some application has succeeded in implementing gamification to their platform, for example, Duolingo (www.duolingo.com). Most have used the approach to use rewards, gain badges, or receive points from their users. One can, for example, gain points from logging in or posting a picture (Law et al., 2011). Areas that are frequent users of gamification are healthcare and wellness applications. It has shown a positive impact on engagement while users benefit from healthier outcomes. However, even here, there is lacking support for long-term engagement from the users. As Stepanovic and Mettler (2018) argues in their research that" (...) long-term engagement and continuous use can surely be considered as relative concepts." (Stepanovic & Mettler, 2018, pp.5). One cannot say for sure that gamification works long-term and, at the same time, leads to more healthy behaviors. Some have only provided gamification as a way to provide feedback to the users, to visual data, or to motivate users with their performance (Stepanovic & Mettler, 2018).

4

Methodology

The Methodology chapter will explain some design processes and methods used during the project. It will further show how the project used the approaches of *Research Through Design* and *Design Thinking* as well as mentioning design processes that have influenced our design process in the project, such as the *Hasso-Plattner or d.school Design Thinking model*. The methods mentioned are divided into five different categories; *data collection*, *data analysis*, *ideation*, *prototyping*, and *evaluation*.

4.1 Research Through Design

Research Through Design "(...) recognizes the design process as a legitimated research activity, examining the tools and processes of design thinking and making within the design project (...)" (Martin & Hanington, 2012, pp.184). This is used to develop knowledge to enhance design practices, but Research Through Design involves more than the design process. It includes material research, development work, recording and communicating steps, experiments, and iterations. Designers research secondary design and then combine it with explorative research using different methods. The designers' goal is to start to form a problem and arrive at the right solution, and the artifact that comes from this process can be sketches, models, and prototypes (Martin & Hanington, 2012, pp.184).

In contrast, *Research Through Science* uses the characteristics of *falsifiability* and *scientific research programs*. Falsifiability means disapproving theory by the incompatible result from observation or experiment. This process creates an evolution of theories" (...) by eliminating weaker theories, only the stronger will survive." (Gaver, 2012, pp.3). Scientific research programs are mentioned in Gaver (2012) as something that emphasizes scientific activity rather than individual theories. Programs are characterized as the hardcore of theory, surrounded by a protective belt of hypotheses and other powerful problem-solving mechanisms used to produce evidence to further make it capable with the theory.

In the case of Research Through Design, these two mentioned approaches are not as simple to work into research.Gaver (2012) explains that design theory is unfalsifiable

because the design is often addressed as wicked problems. It is also considered being generative because the design is often very complex, and no correct solutions exist before informing how to address it, and" (...) design is concerned with creating what might be (...)" (Gaver, 2012, pp.5). What Research Through Design lacks is ideals and patterns, a shared paradigm, as exists in scientific research. If existing, it would further make experts in the area work together to help design research progress by creating standards and agreeing on issues. Gaver (2012) mention that people working in the design field most of the time have shared values. Although researchers in HCI are not engaged in theories involving research design to create guidelines and practice, they, however, are frequent users of design techniques and orienting concepts. They often look at examples of design to create their design ideas.

4.2 Design Thinking

Design Thinking is more of a general approach and mindset rather than an exact method, meaning that there is no single definition for Design Thinking (Tremosa, 2022). The Interaction Design Foundation describes Design Thinking as a methodology that provides a solution-based approach to solving complex and wicked problems. Design Thinking is human-centered, which means that the human perspective should be involved throughout the whole process. It is also known for allowing more thinking outside the box than most other types of design processes and for being flexible because it is both non-linear and iterative (Interaction Design Foundation, n.d.). When using Design Thinking, the designer needs to consider what users want, what is available in materials and resources, and the constraints of a project. Considering these things requires the designer to think in a way where feelings and emotions are as important as rationality (Tschimmel, 2012).

There are several models describing a Design Thinking process. Our main design model, the Hasso-Plattner, also known as the d.school Design Thinking model, will be described in more detail in Section 4.3. Other examples are the *3 I model* made by design agency IDEO and the *Double Diamond* model by the British Design Council. (Tschimmel, 2012). These two models will be explained in the following parts.

4.2.1 3 I Model

The *3 I* model was created by IDEO in 2001. It is based on the 3 I's; *inspiration*, *ideation*, and *implementation*. The Inspiration phase is about identifying the design problem and observing the target group in their daily living environment. The ideation phase looks at what they have observed or learned and transforms this into opportunities to change and ideate solutions. Lastly, the implementation phase turns the best ideas into prototypes and tests them, working iteratively (Tschimmel, 2012).

4.2.2 Double Diamond Model

The British Design Council developed the Double Diamond design process model in 2005. The model shows how the project diverges and converges during the design process, creating a double diamond shape. It is also called the 4 D model because each phase starts with the letter D; *Discover*, *Define*, *Develop*, and *Deliver*. New information about opportunities, markets, trends, and insights is researched in the discovery phase. These are reviewed and then selected or discarded in the define phase to focus the project more. In the develop phase, solutions are created, iterated, and tested. In the last phase, deliver, the final product is tested and launched (Tschimmel, 2012)..

4.3 The Hasso-Plattner (d.school) Design Thinking Model

The Hasso Plattner Institute of Design at Stanford, also known as d.school, is considered one of the leading universities in Design Thinking. They have developed a Design Thinking model consisting of five phases; *Empathize*, *Define*, *Ideate*, *Prototype*, and *Test*. The first phase of the process is to gain an empathic understanding of the problem trying to be solved. This information defines the problem through a problem statement in a human-designed matter. In the third phase, ideate, the designers begin generating ideas, some of which are prototyped in the fourth phase. In the fifth and last phase, the product is tested. In the following sections, the phase will be described in greater detail.

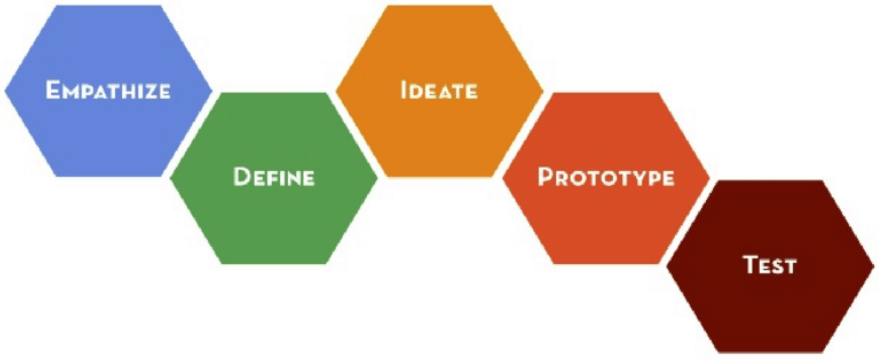

Figure 4.1: Phases in the Hasso-Plattner (d.school) Design Thinking model. dschool.stanford.edu/resources

4.3.1 Empathize Phase

The empathize phase of the Design Thinking process focuses on gaining an empathetic understanding of the problem. Gaining this understanding can be done through observing, engaging, and listening to people's experiences or consulting experts in the field. The combination of both observing and interacting with users can give insights not only about what they do but also their values and why they do things a certain way (d.school, 2010). It can also be a good idea to submerge yourself in the users' physical environment to understand better the problems involved. Empathy is central to human-centered design processes such as Design Thinking (Dam, 2021).

4.3.2 Define Phase

During the define phase, the information gathered from the emphasize phase is further analyzed to create a problem statement. The problem statement is the core problem to be solved during the design process and should be defined in a human-centered manner (Dam, 2021). A more narrowly focused problem statement tends to produce more high-quality solutions. It is, therefore, crucial to have a good understanding of the user and the problem to be able to formulate a good problem statement (d.school, 2010).

4.3.3 Ideate Phase

The next phase focuses on idea generation. The phase is where the design team transitions from identifying the problem to creating solutions. While ideating, one should try to generate various ideas that can be prototyped and tested in later phases. Prototyping and testing the ideas will show which ones work. It is essential to consider that being too critical of ideas too early can stump creativity and should therefore be avoided (d.school, 2010).

4.3.4 Prototype Phase

The prototyping phase is an iterative generation of varying fidelity artifacts that allow interaction with the user. A prototype can have many different purposes, such as generating ideas, testing possibilities, and starting conversations. It can also be part of the ideation phase as prototyping can inspire and create new ideas (d.school, 2010). Finally, prototypes can be tested by both the design team and outside participants and can be used to identify the best solutions for the problem at hand (Dam, 2021).

4.3.5 Test Phase

During the test phase, feedback on the prototypes is inquired from users. Since the d.school Design Thinking model is an iterative process, the results from testing are often used in the other previous phases to understand users better, improve the definition of the problem, generate new ideas, or improve prototypes. During testing, d.school recommends showing the users the prototypes and letting them interact with them, creating experiences for the users, and asking them to compare different alternatives (d.school, 2010).

4.4 Methods for Data Collection

The methods described in this section were used to collect information and data from both literature and users. Collecting the data was central in both the empathize and test phases of the Design Thinking model and is essential to understanding the users.

4.4.1 Interviews

Interviews are defined as a "conversation with a purpose" (Preece et al., 2015, pp.197). Interviews can be conducted in person or remotely, and the structure can be adapted depending on the purpose. *Structured interviews* follow a script and tend to feel formal and impersonal for the interviewee but are easier to control when it comes to time and to analyze. *Unstructured interviews* generally follow a guiding set of topics to be addressed in the session, but no exact questions are defined. They are more conversational than the formal ones, but the researcher needs to ensure the relevant topics are being covered. *Semi-structured interviews* use aspects from both. Therefore, they can benefit from the structure of the questions and the flexibility of exploring interesting topics that surface further. (Martin & Hanington, 2012).

4.4.2 Literature Study

Literature studies are a form of secondary research that can be a valuable component to design projects. Research on a topic is summarized and distilled in a literature study to inform the new project. The information is often presented in a sorted way by research categories. However, it can be presented in chronological, thematic, or methodological order if that is a better fit. The information should preferably be collected from published sources such as books, chapters, journals, and theses but could also come from corporate and academic blogs and documented design projects. It is essential to select credible sources for a literature review (Martin & Hanington, 2012).

4.4.3 Questionnaire

A questionnaire is a method for collecting demographic data and participants' opinions. They benefit from being easily distributed to many people and can be spread online and in person. A questionnaire can contain many different types of questions, such as closed-ended questions, open-ended questions, Likert Scales, and the participant ranking different options (Martin & Hanington, 2012). Questions must be worded carefully as the researcher cannot clarify the meaning to the participants once the questionnaire is distributed (Preece et al., 2015).

4.5 Methods for Data Analysis

The method in this section was used when analyzing data collected during the project. This method was *Affinity Diagramming*, which was mainly used during the define and test phases.

4.5.1 Affinity Diagramming

Affinity diagramming is a common technique in qualitative analysis where the activity consists of team members writing ideas or facts on sticky notes. The notes are sorted into categories and occasionally prioritized (Pernice, 2018). It can be used to understand the context of the problem and analyze the results of user testing. It can also be used for organizing and creating a hierarchy of ideas, themes, and insights. Affinity diagramming is an inductive process, meaning that the themes are not predefined but emerge during the process (Preece et al., 2015).

4.6 Methods for Ideation

This section describes brainstorming methods, design workshops, mind-mapping, personas, and storyboarding. During the ideation phase, these methods were used to generate possible solutions to the research problem.

4.6.1 Brainstorming

Brainstorming is a technique commonly used by design teams to solve design problems. A brainstorm rapidly generates, defines, and develops ideas that could be potential solutions to the design problems (Preece et al., 2015). Brainstorming is a part of Design Thinking and is often used during the ideation phase. There is often a facilitator to keep the brainstorming on track, but the participants are encouraged

to explore outside-the-box thinking to produce as many ideas as possible. Different techniques within brainstorming can be used to push for creative ideas, such as brainwriting, the *worst possible idea*, and *mind-mapping* (Dam & Siang, 2020). Some general rules are encouraged to be followed during a brainstorming session. These are to have a sharp focus on the problem to solve, use an ice-breaker exercise and make things fun, and stay away from being overly critical of ideas too soon (Preece et al., 2015).

4.6.1.1 Brainwriting

Brainwriting is a brainstorming method used to generate ideas rapidly. Participants are asked to write or sketch their ideas on paper rather than saying them out loud, resulting in more ideas than in a traditional brainstorming session. Brainwriting can be done individually or interactively with a group of people. If done interactively, each member gets a few minutes to write and sketch ideas before passing the paper on to another group member. This member gets to add to the ideas, and this process is repeated several times. In the end, the ideas are collected for future review or voted on by the group. The *6-3-5 brainwriting method* is a specific type of brainwriting where six members each sketch three ideas for five minutes before passing the paper on to the next participant (Wilson, 2013).

4.6.1.2 Starbursting

Starbursting takes an investigator approach to the brainstorming method by asking the questions of *who*, *what*, *when*, *where*, *why*, and *how* concerning a new idea or concept. This method is explorative because one question often leads to another. The method is also effective when building on ideas and concepts when making connections from the brainstorming session. The main idea is placed in the center of a star diagram, and each point of the star is labeled with the questions (who, what, when where, why, and how). The participants then write answers next to the corresponding points of the star. The result is then a representation of well-developed answers to relevant questions to an idea (Gillum & Williams, 2021).

4.6.2 Design Workshops

Design Workshops are a form of participatory design where the design team plans and organizes a workshop for people outside of the design team (Martin & Hanington, 2012). They can be used to rapidly generate and discuss design ideas that the design team might not have come up with themselves. A design workshop is informal and often entails several design methods that can use tools such as sketching materials or other low-fidelity prototyping tools (Kaplan, 2019). A benefit of conducting these workshops in a group of participants is that people are often more comfortable sharing their experiences in a group setting. Therefore, this can bring up different

ideas and discussions from members than if they were to design individually. According to Martin and Hanington (2012), it is essential to stay on track but be adaptable to changing circumstances. Design Workshops are most commonly used in generative research. However, they can also be used for evaluation where the participants can collectively review concepts and contribute insights for the next iteration of the design (Martin & Hanington, 2012). After the design workshop, the design team can decide upon what ideas to continue working on outside of the workshop (Kaplan, 2019).

4.6.3 Mind Mapping

Mind mapping is helpful when having a complex problem that needs to be divided into different parts. This method can help organize a problem space visually to understand it better. Mind mapping is a tool that helps generate ideas and develops concepts while at the same time drawing up relationships between them to make the information clear. Humans often think in a non-linear way, making it harder for us to see patterns regarding complex problems that do not follow that way of thinking and can be hard to visualize. A mind map can reflect ones thinking regarding the complexity of the problem because of its diagrammatic nature that is easy for our heads to interpret, communicate and store information. After the mind map has taken shape, it allows testing assumptions while making and breaking connections to see alternative patterns. Afterward, be used to recall the problem space (Martin & Hanington, 2012).

4.6.4 Personas

Personas are defined as "(...) fictional characters, which you create based upon your research in order to represent the different user types that might use your service, product, site, or brand in a similar way." (Dam & Siang, 2021). Personas can be used when developing ideas and discussing design decisions throughout the design process. They can help a design team ask the right questions and keep the focus on the users (Dam & Siang, 2021).

4.6.5 Storyboard

Martin and Hanington (2012) explain that storyboards visually capture essential social, environmental, and technical factors related to a product. It is important to understand these to see the context of how, where, and why people engage with a product. When making a storyboard, it is necessary to remember the target audience. Remembering the target audience will affect the structure and look of the storyboard to make sure the purpose is fulfilled for the specific group (Martin & Hanington, 2012).

4.7 Methods for Prototyping

A prototype is the physical realization of a product or interface for development and testing purposes. Prototyping is a critical part of the design process for transforming the more abstract work of research and ideation into a tangible product (Martin & Hanington, 2012).

A prototype is defined by its level of fidelity. *Low-fidelity prototypes* are often made early in the process and are used for internal development purposes. Low-fidelity prototypes can be sketches, storyboards, paper prototypes, and wireframes. Wireframing is a form of low-fidelity prototyping where the interface is created using paper or a simple digital sketch. It is a quick and cheap way of identifying usability issues early in the process before committing to an idea. High-fidelity prototypes are more refined and closer to the final look and functionality of the product. Therefore, they are used in the later design process phases to get more thorough feedback. Prototypes can also be in the form of videos and sounds since these mediums can communicate certain aspects of the product that can be difficult to visualize otherwise (Martin & Hanington, 2012).

4.8 Methods for Evaluation

This section describes evaluation methods used to test ideas and prototypes. *Concept testing* and *usability testing* were the methods used during the testing phase.

4.8.1 Concept Testing

Concept testing is used to obtain user and stakeholder feedback during the early design process. It allows designers to reduce the risk while increasing focus on the user and stakeholder input and building a product that meets the needs of the target audience and market (Yocco, 2021). Concept testing can be done both online and in-person, in either a group of participants or individually (Rohrer, 2014).

4.8.2 Usability Testing

Usability testing is an evaluation method where users are asked to complete tasks within a system. The tasks given to the users should be specific, concrete, and reflect the actual goals of the target audience. According to Preece et al. (2015), the goal of usability tests is to see if the developed product is usable for the intended audience. The recommended number of participants in usability testing is between five and twelve. Usability testing can give many types of quantitative data such as error rate, success rate, and the time it takes for the user to complete a task (Preece

et al., 2015). To obtain more qualitative data, the *Think-Aloud Protocol* can be used. The Think-Aloud Protocol involves asking the user to verbalize what they are thinking, feeling, and doing during or after the test. Through that process, the team can gain a better understanding of why the user does things a certain way (Martin & Hanington, 2012).

5

Planning

The time plan for this master thesis project can be seen in Figure 5.1 as a Gantt chart. Each task is planned through weeks, starting at the calendar year. The tasks in the time plan are color-coded, displaying the time each step took. The planning report was finished and handed in during week 7. During the planning report phase, some focus was on the empathizing and defining phases of the problem. We looked into the problem statement further and tried to figure out what both Svalna and potential users want and need before moving on to the design process. The report is expected to be finished at week 21, while the presentation will happen around week 22.

Figure 5.1: The time plan for the project thesis displayed as a Gantt chart

5.1 Report Writing, Design Process and Presentation

The project thesis started with writing a planning report, which was partly included in the final report. The planning report includes literature studies and finding overall knowledge over similar scopes to give us a broader idea of subjects relative to our project. The planning report took five weeks to write.

The design process was inspired by the Hasso-Plattner Institute of Design at Stanford design model, see section 4.3. We wrote down short summaries of the process and our thoughts to save our results during the design process. The summaries made it easier for us when writing the final report to preserve the decisions made. The report writing took place after the design process. We used the summaries and

results taken from the design process to write the remaining sections of the report. The preparation for the presentation happened parallelly with the writing. The writing of the report and presentation preparation took around four weeks.

5.2 Research and Collection of Data

The research and collection of data happened during the planning report and the design process. The planning report included literature studies while comparing similar applications. The collection of users' data happened through Svalna's research, interviews, and testing. Collecting the data through the planning report and design process took 15 weeks.

5.3 Concepts Development and Testing

The testing occurred parallel with the concept development. The design process has been iterative, meaning the phases overlapped during the project. We noticed that one iteration was not enough to produce a final result, and we needed to go back in the process again to try other solutions. Therefore, the testing was conducted sporadically for nine weeks. The final testing occurred on the last week of the nine weeks.

6

Design Process

The design process, see Figure 6.1, was an iterative process that started with a literature study and an empathize phase to learn more about the topic and Svalna's current and potential users. We wanted to know what they might need to encourage long-term use of a carbon calculator, which later helped define the problem. Next, the ideation phase included brainstorming ideas from users, Svalna, and us to develop concepts. This phase also included answering questions relative to the problem using different methods. Low-fidelity and high-fidelity prototypes were created in the prototype phase to make the concepts tangible. Lastly, these prototypes were tested on potential usability simultaneously throughout the prototype phase to reach the final refined concepts.

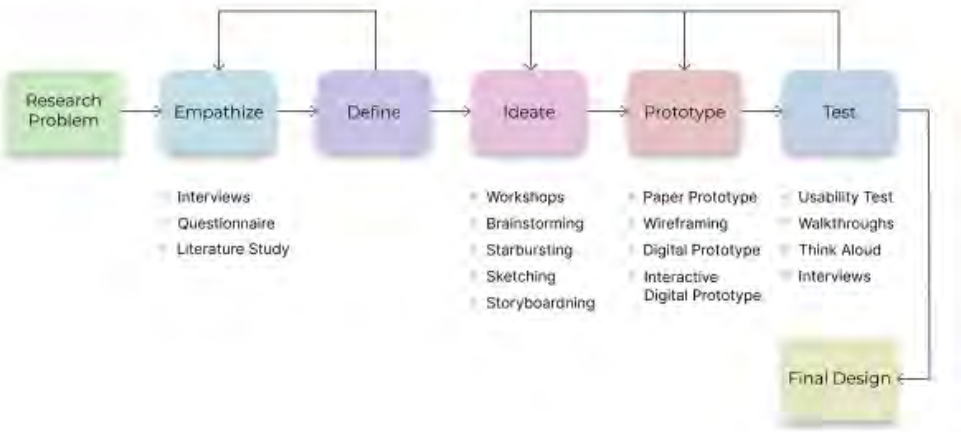

Figure 6.1: Overview of the design process and the methods used in each phase.

6.1 Literature Study

A literature study was conducted to gain knowledge of previous research about the long-term use of carbon calculators. The study was to find the gap this thesis would aim to answer, also known as the research question. The literature study included topics such as carbon calculators, long-term use regarding routines and habits, and appropriate methods that could help solve the research question.

6.2 Empathizing with the Users

To empathize with the user, we used the process of a questionnaire and an interview. The first section is about the questionnaire, which aims to gain fast information regarding climate and application use. The last part, the interview, goes deeper into the questionnaire's answers to understand users and their engagement in the climate, application use, gamification, and feedback.

6.2.1 Questionnaire

A questionnaire was conducted at the beginning of the empathize phase. The goal of the questionnaire was to get a better understanding of users' views on climate change and more about their daily habits regarding application use. The questionnaire was conducted online using Google Forms and then distributed to other interaction design students through Slack and friends and family. The questionnaire also informed the participants about their rights regarding GDPR and other rights.

The questionnaire had a mix of open and closed-ended questions about three different topics relevant to this thesis; climate change, application use, and carbon calculators. Some questions asked the participants to choose options from a list, while others asked for a longer explanation. Some of the questions were also optional to answer. The questions regarding climate change were about what they tried to do for the climate and what they found hard with it. The questions about the application use were to better understand which application each participant used long-term (daily, weekly and monthly) and later study these application structures further. The last questions regarding the carbon calculator were to see how many had used one calculator before and how they interpreted the results. Another aspect was to see if their environmental behavior changed afterward and for how long.

6.2.2 Interviews

The answers from the questionnaire were the basis for an interview to further answer some of those questions. An interview was necessary to understand the user better regarding the previous topics of climate change, app use, and carbon calculators because participants in the questionnaire had given various answers. The expectation by doing an interview was to give this project a better sense of how people feel about the environment and maybe understand what interests them individually and what feedback they want from carbon calculators. We wanted to explore if notifications and gamification could be ways to engage people more about climate-related issues.

The interview had four categories: climate change, feedback systems, gamification, and carbon calculators. The questions were semi-structured to give the interviewer

and participants space to add related subjects and thoughts regarding the question from the interview and the answer given by the participant. Three participants participated in the interview. The results were then sorted and structured using the Affinity Diagram method.

6.3 Ideation of the Concepts

The ideation phase includes two workshops and a brainstorming session. The workshops aimed to get participants and Svalna to generate ideas that could inspire further during our brainstorming session. The brainstorming session contained rapid ideation, mind mapping, Brainwriting, Starbursting, sketching, and storyboarding.

6.3.1 Workshops with Students and Svalna AB

At the start of the ideation phase, two design workshops were conducted — one with student participants from Chalmers University of Technology and another with employees at Svalna. The workshops aimed to collect ideas and design solutions to the research problem from potential application users and Svalna themselves.

The first workshop was located at the university campus at Lindholmen and had five participants. The workshop format included an icebreaker, a group exercise, and an individual exercise with a discussion following each part. The icebreaker asked the participants to draw their favorite animal to encourage them to draw and talk to each other. The group was then divided into two smaller groups to conduct an extreme character exercise. The cards were created in Figma (www.figma.com/) and showed an image, name, description, and quote from the characters; see Figure 6.2 for card examples. Each group picked two cards, some of which displayed real people, and some were made up. The participants discussed potential design solutions catering to the two characters for 15 minutes and then presented them to the whole group. Figure 6.3 shows participants from both the workshops doing the exercise. The second part of the exercise was for the groups to take two additional character cards, which forced them to change some of the previous ideas for another 15 minutes. We then asked them to present their new ideas as well.

The second exercise in the workshop used Brainwriting as a method, which is explained in Section 4.6.1.1. The participants were asked to rapidly sketch their solutions to encourage long-term use regarding the Svalna application. Each participant started by sketching down three ideas in five minutes and then passed them on to another participant in the group. They were then given the option to extend the existing ideas or add new ones to the paper, and the exercise finished when all participants had written down something on each paper. The participants were then asked to discuss the ideas.

The second workshop with Svalna was supposed to be with four people but only had

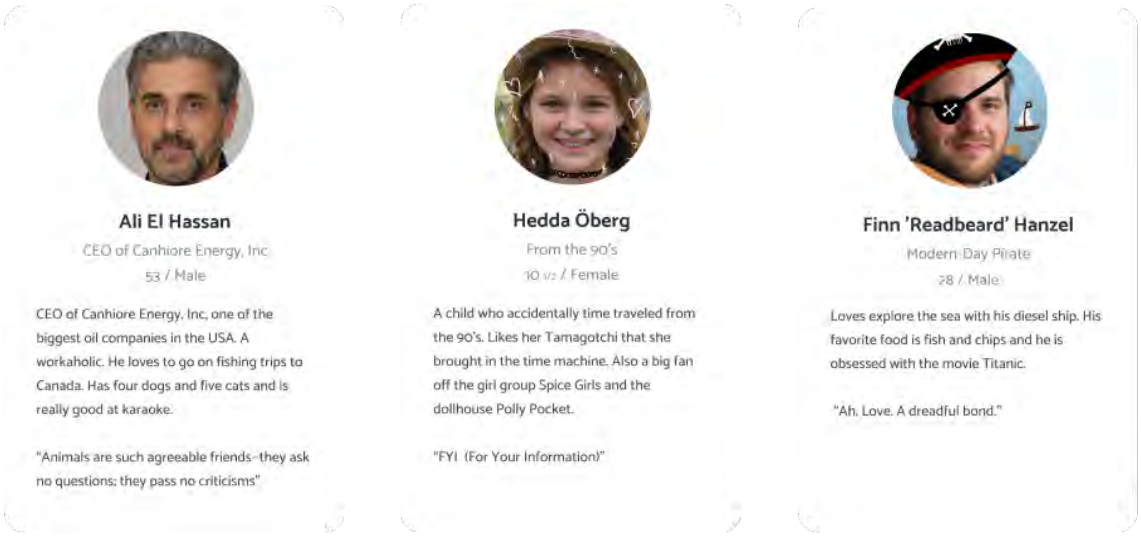

Figure 6.2: Examples of three different extreme character-cards. Faces generated by AI at *www.thispersondoesnotexist.com/.*

two due to absences. Only the first exercise with the extreme characters was eligible with this number of participants. Instead of the Brainwriting, a discussion was held with the employees to learn more about the application and what previous ideas had been explored by the company to improve the engagement in the application.

Figure 6.3: Participants in each of the workshops brainstorming for the extreme character exercise.

6.3.2 Brainstorming Ideas

The workshops served as the basis for our brainstorming session. The brainstorming contained several activities; rapid ideation, Brainwriting, Starbursting, sketching, and storyboarding.

The brainstorming session started with a round of rapid ideation where different ideas were sketched individually for 15 minutes. A rule was set that at least five ideas had to be created each, and each idea was then discussed shortly before moving on to the next step. Afterward, the two most interesting ideas were developed further by using a simplified version of Brainwriting. Next, we sketched one of the two ideas for five minutes before handing it to the other person, who also spent five minutes adding to it. After these ideas had been developed and discussed, three concepts came out of the brainstorming session and were later structured through a mind map.

6.3.3 Answering Questions Using Starbursting

Starbursting was used to define the concepts further. Based on the mind map, we started by making a star for each concept to formulate meaningful questions for the categories; who, what, how, where, when, and why. Some categories got more questions than others because we had already answered a few. After the first star, we noticed that these questions could be used for all of our concepts and ended up with just one star. Afterward, the questions were copied into a document and then answered by us. Answering the questions helped us define and refine the concepts to better understand them.

6.3.4 Sketching the Concepts

Fast sketches of how the ideas could look and work as digital products were made after the Starbursting. The sketching led to different ways of implementing each concept. The different options were then discussed and compared to see how they could work with Svalna's already existing application. The sketches were made on paper and can be seen in Figure 6.4.

6.3.5 Contextualizing the Concepts by Storyboarding

The answers to the Starbursting and the sketches were then visualized into storyboards. The storyboards helped us discuss and add context to how our concepts could be used in practice. Multiple storyboards were created for each concept and sketched on paper.

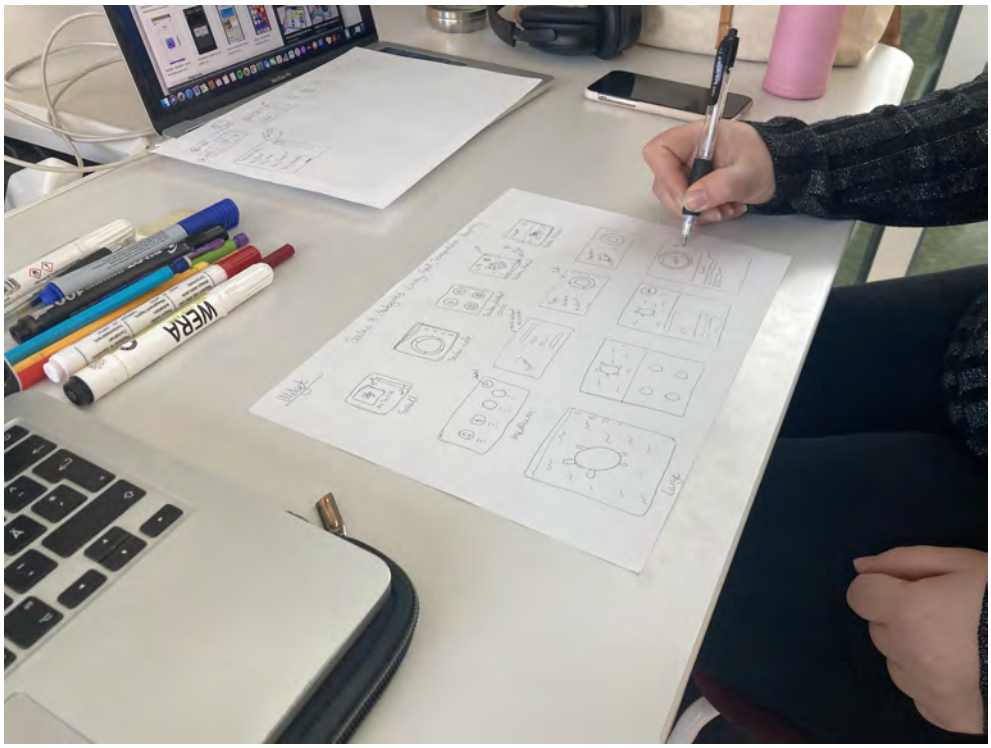

Figure 6.4: Sketching on one of the ideas from the brainstorming.

6.4 Low-Fidelity Prototyping and Testing

The low-fidelity prototyping included two methods; wireframing and paper prototyping. These two methods also included the testing of each concept prototyped.

6.4.1 Wireframing

The wireframing aimed to create a structure for each concept from the ideation phase before creating a more thorough low-fidelity prototype. The wireframing was created to structure how a simple interaction would work and limited irrelevant details early on when designing the concepts. The program Mural (www.mural.co/) made it possible for us to draw up different design concepts and functions regarding the ideas from the brainstorming and storyboarding session.

The wireframes were created with necessary details in mind so that a participant should understand when tested while having the moderator explain the functionality further. The use of arrows symbolized the connections between the frames.

6.4.2 Testing of the Wireframes

The test of the wireframes included an interview with one participant that was present during the student workshop. The testing occurred during the exam period, which made it hard to find participants, but we found that one person was enough for this testing. The testing was to gain feedback on the structure and functionality of the concepts and if they would seem desirable for long-term use. Afterward, an interview was necessary to avoid only applying our perspective on the concepts. The interview was semi-structured, which allowed us to ask further questions.

6.4.3 Paper Prototypes

The wireframes worked as guidelines for creating the paper prototypes of the three concept ideas. As in the wireframes, the paper prototypes only included necessary functionalities and details, such as buttons and short information that would be displayed later in a high-fidelity prototype, see Figure 6.5. The user experiences otherwise present in a more developed prototype were limited. Another purpose was to make the prototypes interactive, meaning that each paper frame was to be manually changed. The prototypes consisted of mainly plain paper while showing smaller frames and buttons using sticky notes.

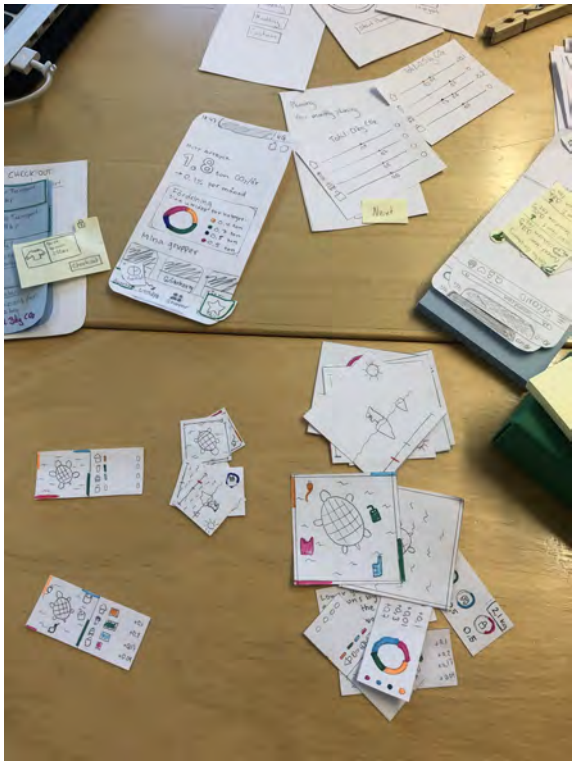

Figure 6.5: The creation of the paper prototypes.

6.4.4 Testing of Paper Prototypes

The testing of the paper prototypes included the method of usability testing together with the Think-Aloud Protocol, see Section 4.8.2, meaning they gave comments about the design while testing it. One of us was responsible for being the moderator, while the other controlled the paper prototypes. The tests were recorded using a laptop to capture the interaction the participants had with the prototypes, see Figure 6.6. Recording allowed us to go back later to watch the interaction between the participant and the prototype and listen to the comments given by the participants. The test was performed on two people who were currently doing a master thesis project for Svalna, meaning they were already familiar with the Svalna application.

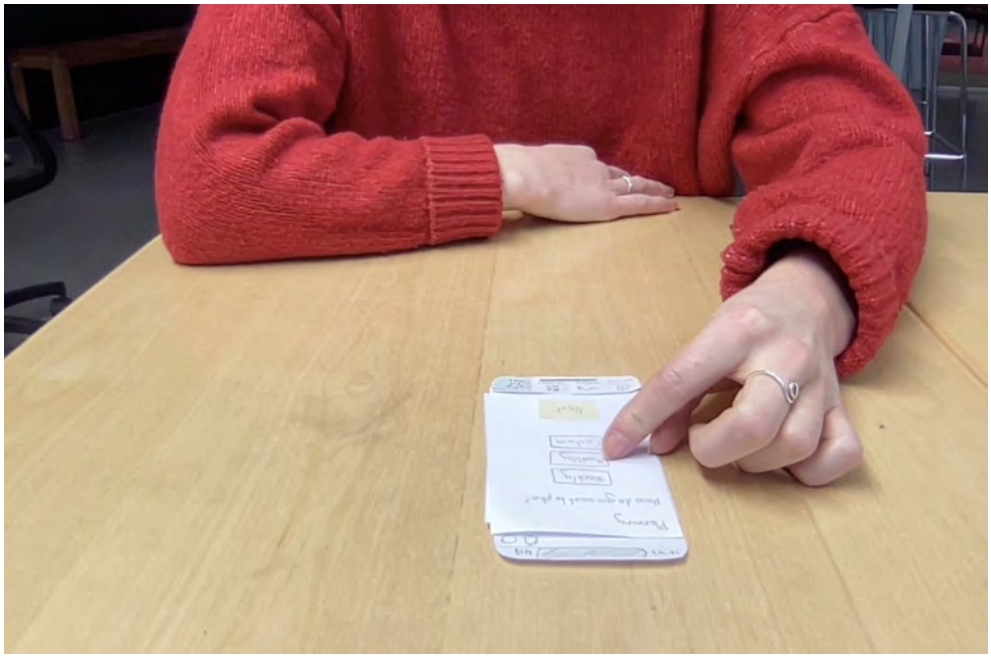

Figure 6.6: Screenshot from the recording of a participant interacting with the paper prototype.

6.5 High-Fidelity Prototyping and Testing

A series of high-fidelity prototypes were created during the final phase of the design process. The phase started with making concept mockups used as the basis for two iterations of interactive prototypes of the two concepts and their testing.

6.5.1 Mockups of Concepts

After the low-fidelity paper prototype, we decided to only continue with two of the three concepts. This was because the plugin concept was not feasible to conduct

with the data Svalna currently use. Concept mockups were made to gather feedback from Svalna. These mockups aimed to explain the concept and show off different ways of implementing it. The mockups used elements from Svalna's own Figma prototype to capture the look and feel of the application and focused on visualizing some central frames of the two remaining concepts. The mockups gave an overall idea of how the concepts could visualize and work while not creating fully detailed interactive user flows.

We began the process by creating a moodboard of how other applications had approached similar design concepts. Looking at other design solutions inspired our approach to similar design problems. Next, Figma was used to create and show five design areas of our concepts; planning, goals, graphs, statistics, and widgets. Several design suggestions were created for each area and used for discussion. Examples of how data could be visualized in the emission overview can be seen in Figure 6.7.

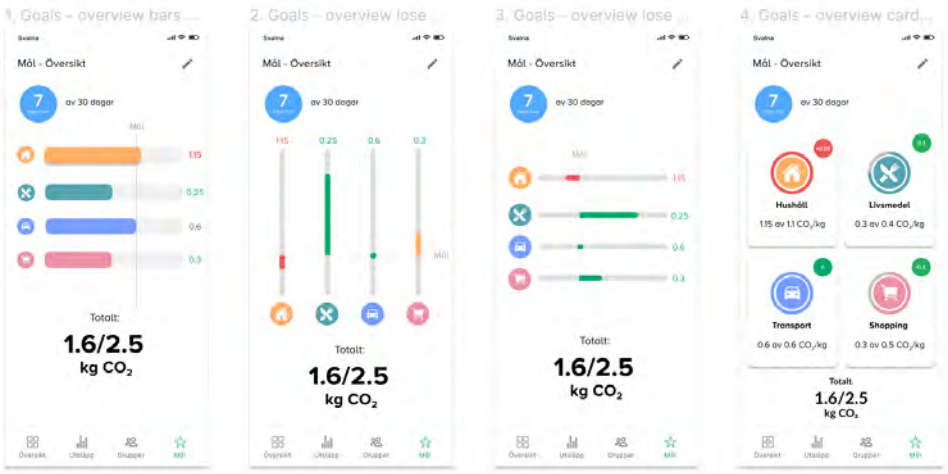

Figure 6.7: Figma frames showing four different options for visualizing data in the emission overview.

6.5.2 Feedback on the Concept Mockups

We showed and explained the prototype to our supervisor at Svalna during an online meeting. First, we pitched each concept and showed Figma frames to support the pitches. Next, specific design variations were shown, and asked for feedback on the designs. Finally, we discussed both concepts thoroughly with the supervisor to make decisions working for Svalna in future iterations.

6.5.3 First Iteration High-Fidelity Prototype

The high-fidelity prototype was made in Figma. The different elements in the prototype were either created by us or taken from the Figma prototype supplied by

Svalna. We created two main flows within the prototype, one for the planning concept and one for the widget. The Figma prototype connections for the widget flow can be seen in Figure 6.8. We also added more details to the prototype than in the concept mockups. These details made the prototype more complete and interactive in this iteration. However, the focus was not on minor details such as the exact sizes of images because they might be changed later. We also looked at the design using a phone to see how colors show up and see if elements are big enough to read or be pressed by a finger.

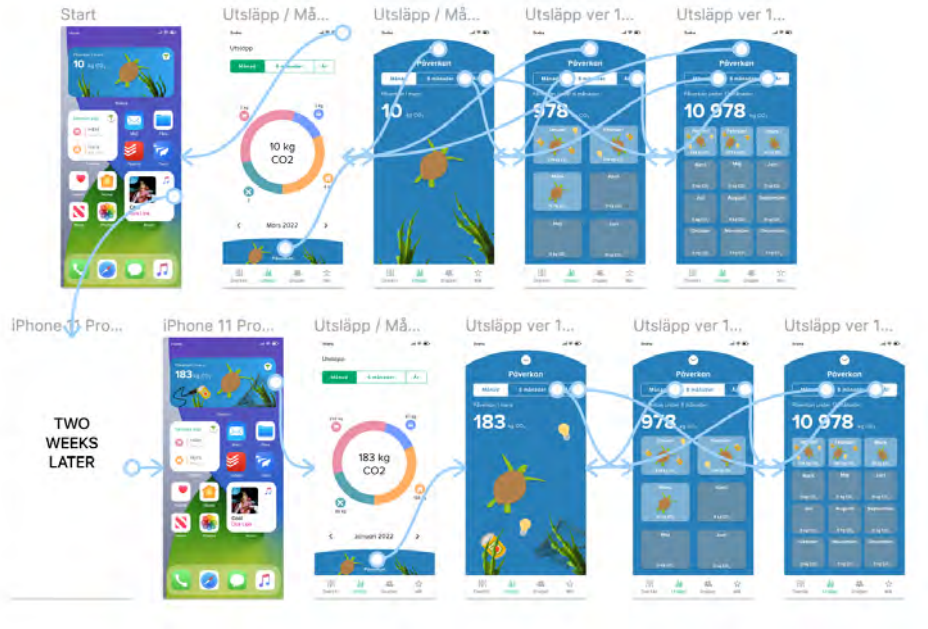

Figure 6.8: The frames connected in Figma for the widget concept in the first high-fidelity prototype.

6.5.4 User Test of First High-Fidelity Prototype

The testing was a modified version of usability testing and had two participants. Each test took approximately 20 minutes. The test aimed to see if the visualizations were intuitive and get input on the basic flows of the applications. As the interactivity in the application was still limited, the tasks for the participants were structured and detailed. One person acted as the moderator to facilitate the testing while the other took notes.

We asked the participants to explain what they thought the numbers signified in the prototype to see if they had the correct understanding. We also asked the participants to use the Think-Aloud Protocol to note their actions and comments.

The test was divided into three parts. Two parts were for the planning concept; selecting personal goals and setting their own goals using the sliders. The last one involved the widget concept and asked the participant to look at the overview of

months. We wanted this test to see if the participant understood the context of the trash showing up around the turtle. The first participant conducted the test on a smartphone, whereas the second used a laptop to navigate the prototype. We used the laptop because a phone with the correct screen size was not available at the moment of testing. After the test, we discussed the results and made a list of changes for the next iteration.

6.5.5 Final Iteration High-Fidelity Prototype

The gathered feedback from the first iteration test required us to change some of the designs. We already knew a few of these design elements would be lacking, but other aspects of the design that we hoped would work got some feedback as well. Changes made included reworking the monthly overview of the widget, changing the trash to a more informational version, and changing numbers in the visualizations in both the planning and widgets concepts. The prototype also needed to be more interactive for participants to explore the functions more in the next test. Figure 6.9 shows the interaction connections added to the turtle for the widget concept in Figma.

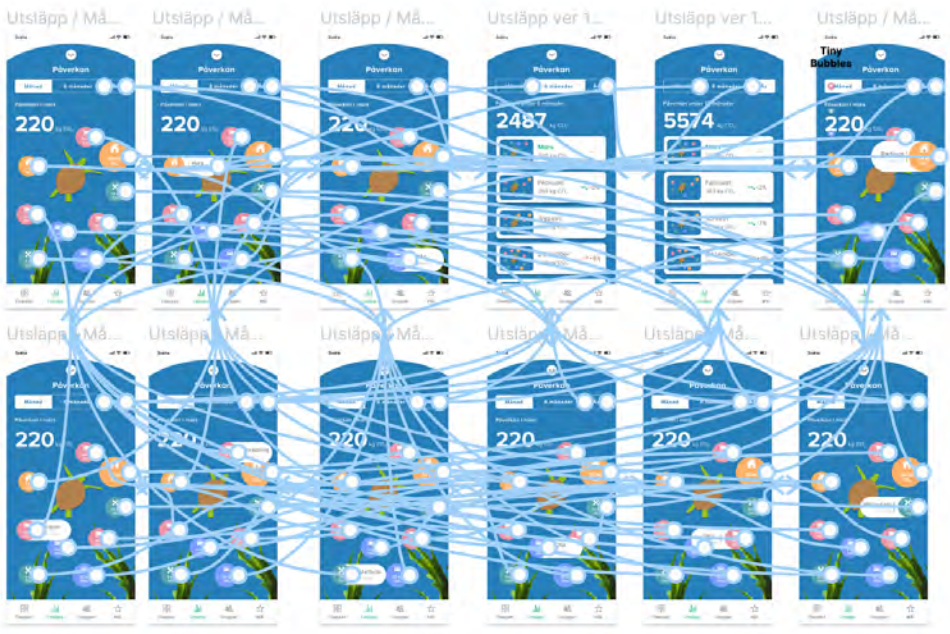

Figure 6.9: The added interaction connections for the widget concept in Figma.

6.5.6 User Test of Final High-Fidelity Prototype

The test was performed on four people, most on a phone prototype through the Figma application, see Figure 6.10. However, one test had to be performed on a

laptop instead of a phone because of technical problems. The test took around 30 minutes for each participant.

This test included a more extensive step-by-step navigational instruction from the moderator. These instructions were to test the concepts and see if the design could stand on its own and if they were intuitive enough. The test included scenarios that the participant had to complete. They were also recommended to speak aloud about what they thought, liked, or struggled with within the design. This time, the interaction in the prototype was improved so that the participants could press and interact more freely than in previous prototypes. This interaction advancement was to see if they could find their way around the prototype or if they could learn where to go. In addition, the scenarios were meant to be repetitive to see learnability within the design.

Figure 6.10: A participant performing the final test on a smartphone displaying the prototype.

7

Results

This chapter presents the results of the different activities conducted during the design process. These activities aimed to answer the research question of getting users to engage with the Svalna application long-term and influence them to adopt a more sustainable lifestyle, fully explained in Section 1.1.1. These included sections present the results chronologically, starting with the literature study and ending with the final user testing. The execution of the design process can be found in Chapter 6.

7.1 Empathizing with the Users

This section shows the results from the questionnaire and interviews conducted to empathize with the users. It breaks down the questionnaire answers into numbers and graphs. It also summarizes the thoughts and opinions from the interviews regarding the climate, application use, gamification, and feedback.

7.1.1 Questionnaire

In total, the questionnaire got 15 answers. Out of these replies, seven were from men, and eight were from women. Eleven participants were between 18 and 29, whereas the other four were between 30 and 39.

All participants claimed they cared about the climate, with the mean being a 4/5. People's most common environmental choices were recycling, using public transportation, and using reusable bags. The least chosen options were to save water, compost, use a travel mug, and buy second-hand. More details can be seen in Figure 7.1. The results also showed that about half of the participants shop equally in-store and online (53,3%). A third (33,3%) shop mainly online, and 13,3% shop mainly in physical stores. The most common emotions related to climate change were sadness and fear, but many also answered anger and curiosity. Boredom and no emotions were picked once, and no one felt happiness or relief regarding the climate. More details can be seen in Figure 7.2.

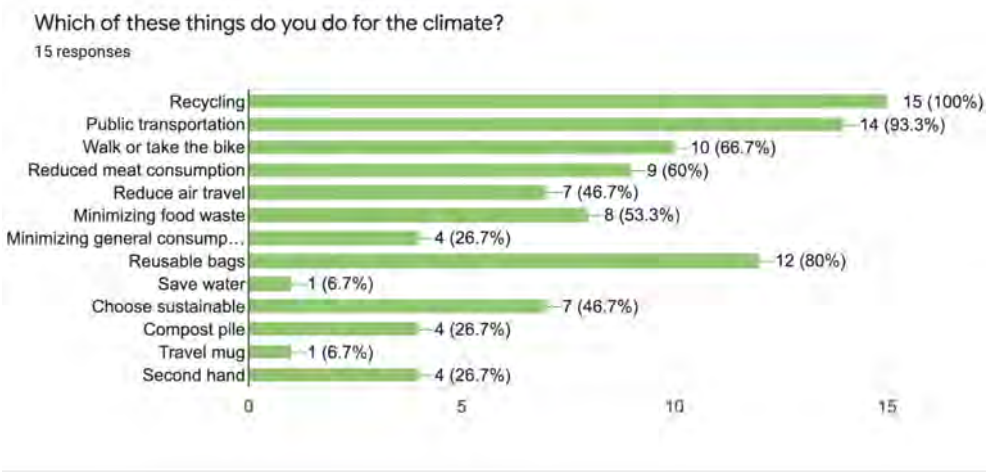

Figure 7.1: The most common environmental actions taken according to users answering the questionnaire.

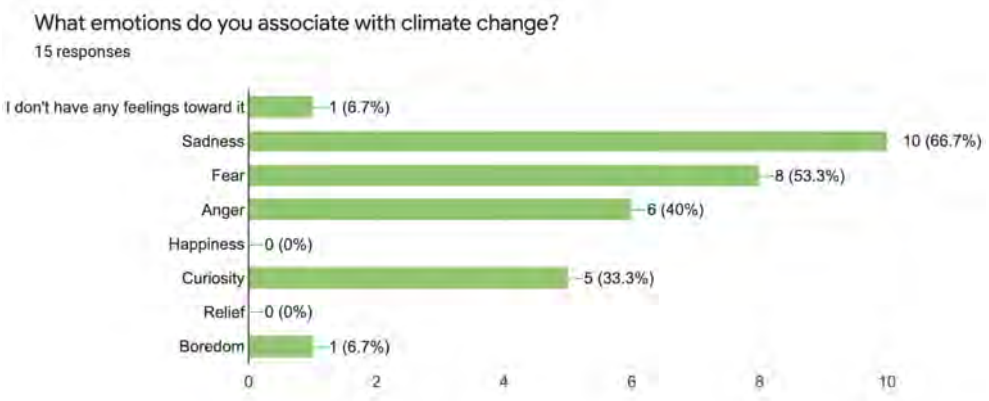

Figure 7.2: Feelings regarding the environment from users answering the questionnaire.

The questions related to applications got 41 examples of applications being used daily. The most common category was *communication*. Thirty-four applications were used weekly, with the most common category being *finance*. Monthly, 17 applications were mentioned, and the most common category was *tools*. As for the questions about application feedback, all participants used notifications on some level, whereas only 40% used widgets.

As for the questions about carbon calculators, eight participants (53,3%) said they had used a carbon calculator before. Out of these participants, most said they found the experience interesting. In contrast, others questioned the results because the calculator did not account for certain factors, and the emission numbers seemed hard to understand. Some felt surprised and fired up to change things, whereas others did not feel any strong feelings toward it. The participants generally trusted

the results from carbon calculators on a medium level, with the mean being 3,5/5. 50% of the participants thought their experience with a carbon calculator changed their behavior slightly, 25% thought it changed significantly, and 25% did not think the experience changed anything.

7.1.2 Interview

The result from the interview showed a variation of answers to the given questions that afterward was structured through the affinity diagramming; see Figure 7.3 for an example. There was a variation of feelings regarding the individual responsibility for the climate, but everyone interviewed agreed that climate change is a global issue. All participants confirmed that they do something for the climate, while some had a more extended list of actions on improving their impact. The participants also felt they did not do enough for the environment, even the ones with the extended lists. They said that existing guidelines were lacking or missing, and finding the courage to do more could be challenging and uninspiring. The mentioned obstacles, finances, motivations, and social aspects, also factored into why they could not do more for the climate. Traveling and lifestyles were especially hard to change, especially when one is doing more than others. Researching was another obstacle mentioned. They argued that one could not investigate the impact of everything they buy or do. They also said that politicians around the world should take responsibility and guide us on how we can succeed in reaching the goals of the Paris Agreement. Businesses should also take responsibility for limiting their carbon emissions because they leave a larger footprint on the climate than general people.

The response to the carbon calculators was that they were somewhat helpful in getting an overview of their carbon footprint and emissions. Two of the participants answered that the results boosted them to do more, while one did not feel any impact. However, the result from a calculator could sometimes feel too general and that it just feels too large and not graspable enough. The participants mentioned that the visualization of the footprint could be hard to interpret and what numbers and diagrams mean on an understandable level. Also, there was uncertainty about what the resource globes often used in carbon calculators meant. For example, what resources do they empty? Finally, they felt that carbon calculators often show only the results but not enough feedback on improving one's footprint. The participants mentioned they would like more feedback involving transport, products one buys online and food from abroad, second hand versus new, leisure trips, and general consumption. They also would like to know and see what one's lifestyle should be like to meet the Paris Agreement and how much one must change.

Lastly, the result showed similar answers from the participants about the feedback system and how they would like to receive feedback from a carbon calculator. Everyone agreed that mail and SMS were the worst way to receive feedback and that they would often discard them instead of reading them. All of the participants used some application notifications as reminders. Some even had notifications enabled on applications, even if they considered the notification to be unnecessary. One fre-

quent answer among the participants was that they would like to schedule getting notifications from carbon calculators because it could otherwise feel disruptive or annoying. The purpose of the notification could be lost. The participants used widgets for weather, clocks, and news. One person felt that widgets could be stressful or did not reveal all information at once, so they felt useless.

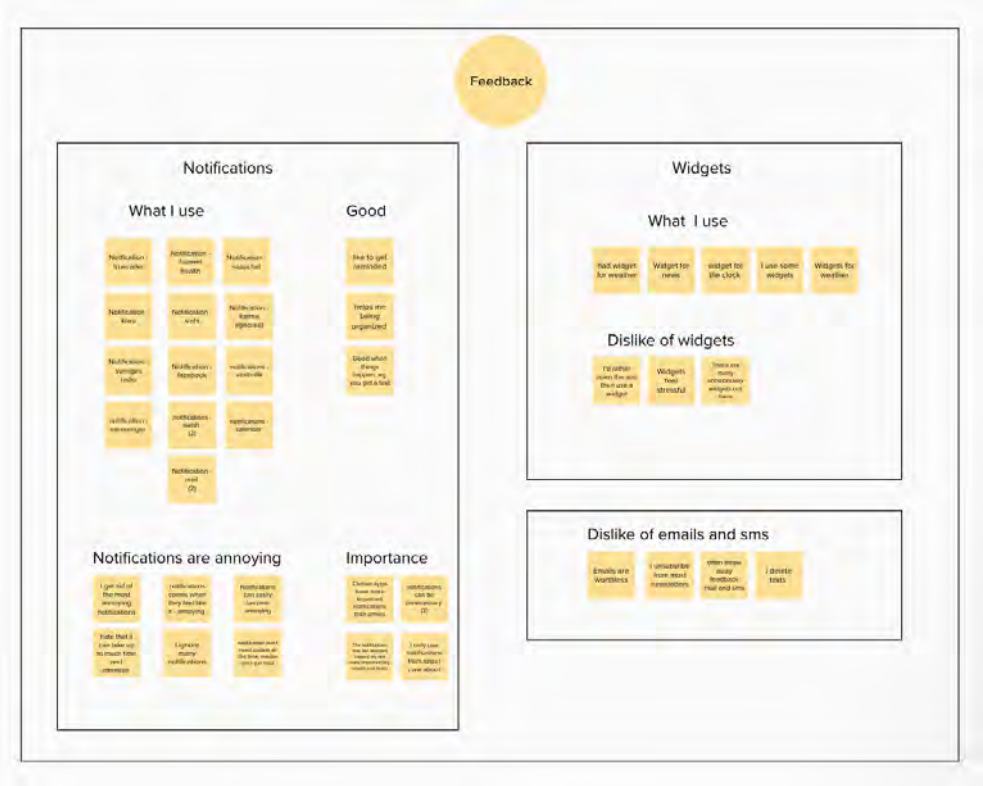

Figure 7.3: An example of the affinity diagram created from the interviews.

7.2 Ideation of Concepts

This section displays the results from the ideation phase of the design process. It shows results from the workshops and the brainstorming session, which included rapid ideation, mind mapping, Brainwriting, Starbursting, sketching, and storyboarding.

7.2.1 Workshops

This section will describe the results of both workshops separately, explaining what ideas were ideated during them and how these ideas were connected to the exercises. We held two workshops with seven participants in total.

7.2.1.1 Results from the Student Workshop

The first workshop had five participants, all students at Chalmers University of Technology. Out of the participants, three were male and two female, all between 24 and 27.

In the first exercise, the first group picked the cards of Ali El Hassan, a made-up character who was the CEO of an oil company, and Victoria, the Crown Princess of Sweden. The group discussed using emotions to make people make environmental choices. They claimed that they did not think using emotions would work with the CEO and that making using the Svalna application lucrative for him to use would be more effective. A lucrative application could be accomplished through competition, prestige, and prices. As for Victoria, they wanted to go in the opposite direction. They suggested using emotions in the application and having it constantly change depending on environmental impact. Lastly, they emphasized the importance of the application being a positive experience for the users.

The second group picked the cards of Greta Thunberg, a climate activist, and Thea Bruun, a made-up character studying marine biology. They noticed that both their characters were interested in the environment and discussed creating a need for the application in their lives. Making the application more useful could include a calendar with environmental events, collecting vegan recipes, or showcasing environmental-related news. Another topic mentioned was visualizing climate impact by using turtles and plastics in the ocean.

In the second round, the first group picked the cards of Beyoncé, the American singer, songwriter, and actress, and Ursula, the antagonist in The Little Mermaid. They discussed comparing the environmental impact of different companies in the application and a browser plugin to encourage sustainable choices. They also suggested including a travel planner in the application to propose more sustainable choices. Lastly, they suggested being able to set goals in the application and cooperating with others to reach them. They emphasized the importance of providing tips and taking small steps not to overwhelm the users.

The second group picked Peter Pan and Hedda, a made-up character who was a young time traveler from the 90s. In this case, the group discussed making the application more suitable for children by making it more fun and relating the information to things children like. They also wanted to include environmental information in the application to teach about sustainability. Finally, there was a suggestion to include inspiration from the children's idols and focus more on competitions and games within the application.

In the second exercise, several design solutions were sketched. These included personal goals to motivate users, focusing more on the competition between friends, a browser plugin giving sustainable recommendations, an event calendar for sustainable initiatives, a dashboard with relevant news and recipes, and a turtle to care for by making environmental choices. A sketch of the event calendar concept can be seen in Figure 7.4.

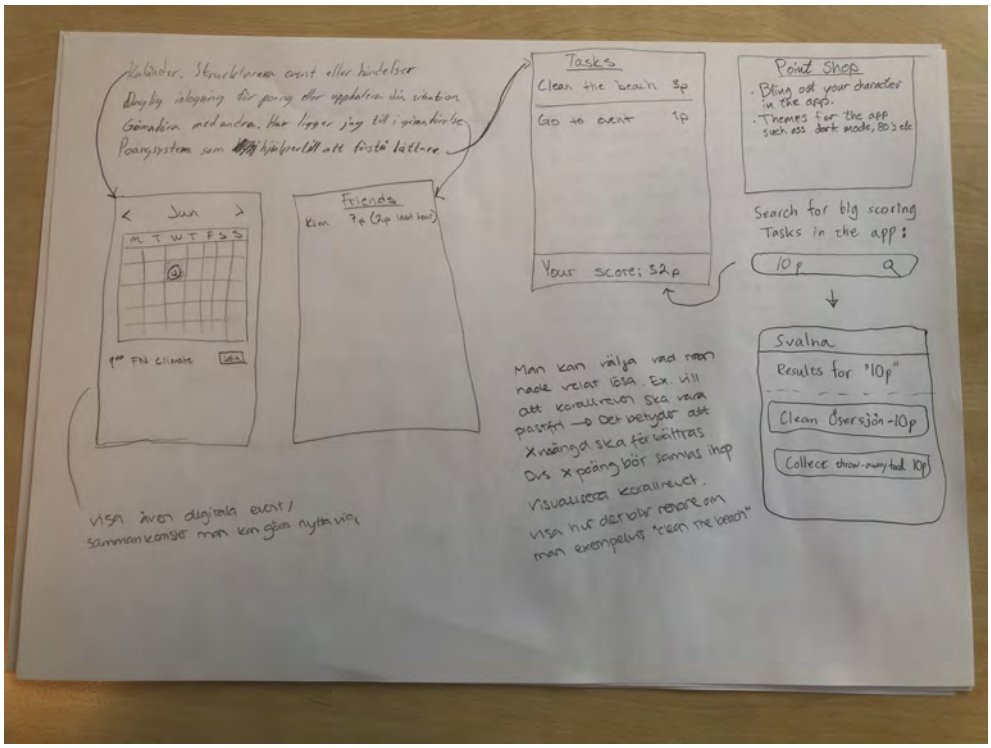

Figure 7.4: An example from the brainwriting exercise showing how a calendar for environmental events could be implemented in the application.

7.2.1.2 Results from the Svalna Workshop

The workshop held with employees at Svalna had two participants. For the first exercise, they picked the cards of Hedda, a made-up character who was a young time traveler from the 90s, and Paris Hilton, the American media personality. For Hedda, they discussed making the Svalna application focus more on games, mainly by letting the user care for a chicken. The chicken concept could also become social by allowing the users to connect and allow their chickens to play. They also discussed ways for Hedda to engage her parents environmentally since she technically could not use the application herself.

As for Paris Hilton, they imagined that she would like the attention for her sustainable choices. Therefore, they discussed using the application to let her promote herself and make her choices look good to the public. In addition, they suggested using the application to allow her to plan her sustainable luxury trips. There was also a discussion about using emotions and showing how terrible the future would be if climate action were not taken. This terrible future could be shown through various visualizations showing how children would suffer and could be directed towards parents. The sketch of these concepts can be seen in Figure 7.5.

For the second round, they picked the cards of Peter Pan and James Bond. For Peter Pan, they noted that he liked adventures and suggested adding challenges to the application. These challenges could include not flying for a year, repairing

something, or visiting an eco-friendly destination. For James Bond, they discussed focusing more on the design than the application's functionality and keeping everything very stylish. They also mentioned good safety and encryption within the application as a selling point for James Bond and to focus the application more on competition rather than collaboration.

Instead of the second exercise, we had a discussion with Svalna about their application. We discussed the application's limitations and what amount of details was realistic to expect from the data. They also told us what they were currently working on within the application and if it could be related to our project. We also discussed their attitude and experiences towards topics such as gamification, notification, and collaboration with other companies.

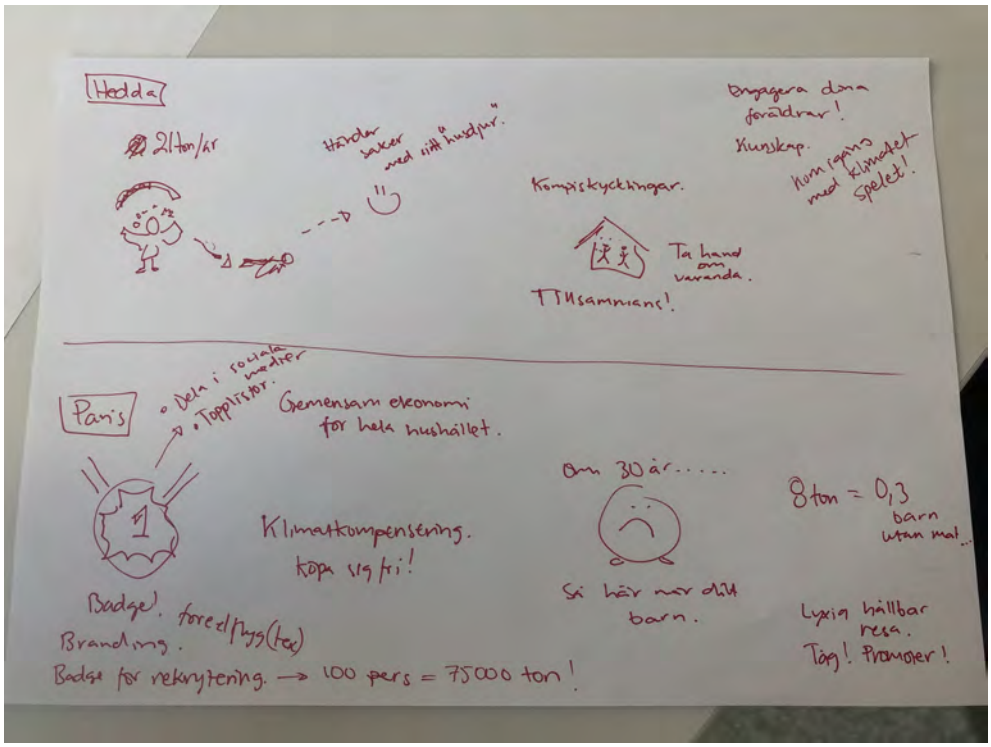

Figure 7.5: Sketches from the extreme character exercise during the Svalna workshop.

7.2.2 Brainstorming

The brainstorming session began with rapid ideation with the goal of coming up with five ideas. In the end, we ended up with six ideas each; see Figure 7.6 for an example of the rapid ideation. Some of the ideas were similar, especially those inspired by the result of the workshops. To further develop the ideas, we held a Brainwriting session. Again, most of the ideas were similar but with some minor differences. Afterward, we picked out three ideas from these sessions to evolve them into concepts, and these concepts ended up being: a plugin, a widget, and a planning feature. We then used

the method of mind mapping to cluster the concepts, for example, in Figure 7.7. Mind mapping was to easier see connections by creating subject branches within each concept. Three potential concept solutions came out from the brainstorming session.

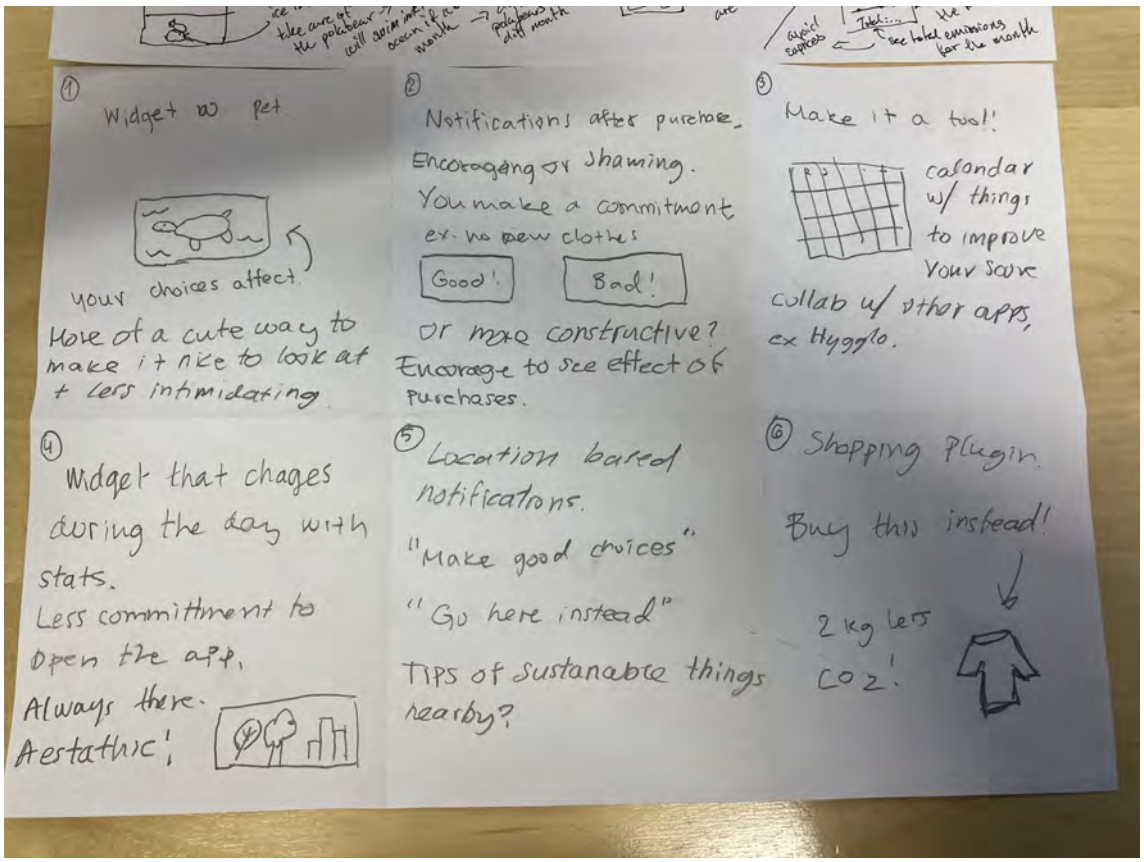

Figure 7.6: A sketch from the rapid ideation session.

7.2.3 Starbursting

Using Starbursting to answer relative questions for each concept gave us a better understanding. Several different directions evolved for each concept. However, we also found a lot of commonalities and connections between them, meaning that we ended up with one star for all of the concepts, see Figure 7.8. The concept was answered using results from the interviews and workshops to make sure we had the users in mind. Appendix A shows the full set of the Starbursting questions and answers.

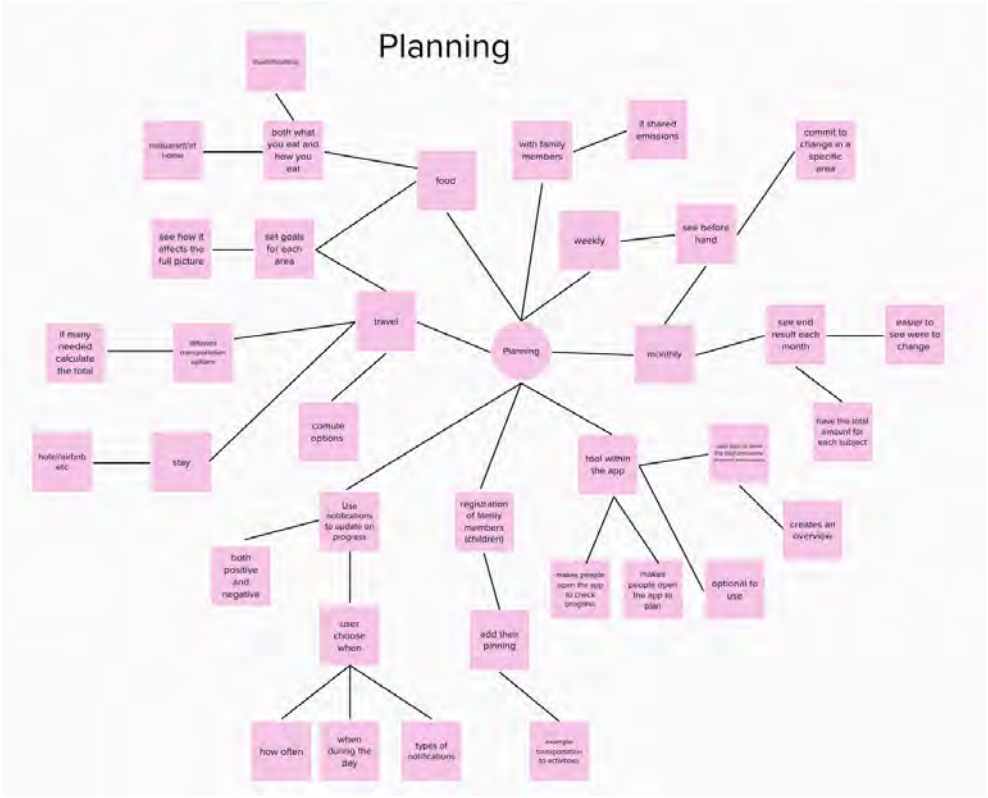

Figure 7.7: The mindmapping for the planning concept.

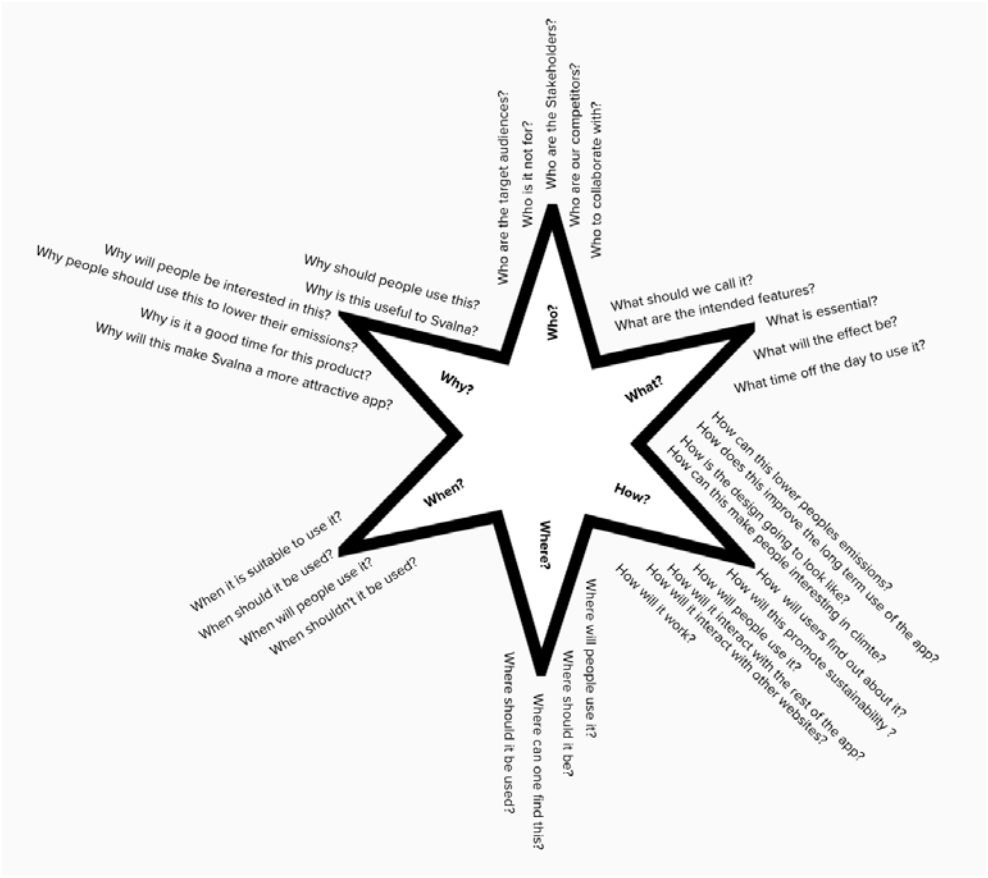

Figure 7.8: The questions that came from the Starbursting method.

7.2.4 Sketching

Sketching each concept made us visualize the questions we answered in Starbursting. We ended up with four pages of sketches in total—one for each plugin and planning and two for widgets; see Figure 7.9 for one of the drawings of the widget concept. The drawings showed different alternatives for the concepts feature and layouts on the screen. Sketching helped us define the concepts even further and discuss various options for them. All the sketches can be found in Appendix B.1.

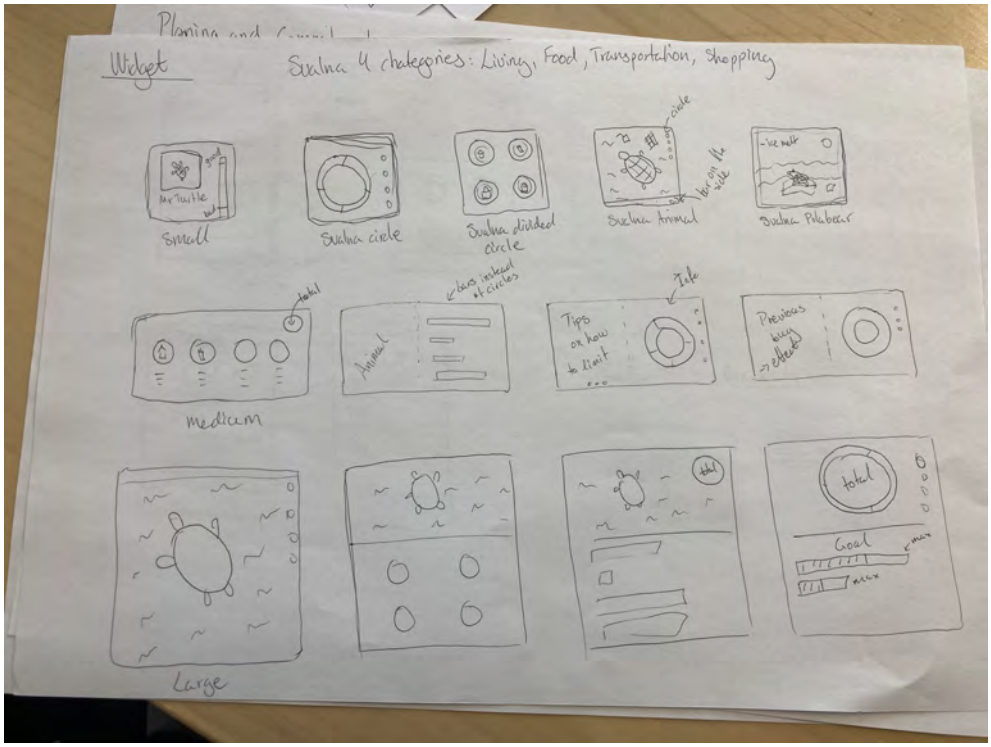

Figure 7.9: An example of the sketches of the widget concept.

7.2.5 Storyboard

We made five different storyboards for the three concepts. Two of the concepts, widget, and plugin, got two storyboards each as we saw different paths of implementing the concepts. The planning concept only had one storyboard. We noticed while doing the storyboard that these concepts could also be connected. For example, the widget could be used to keep track of one's monthly planning.

The storyboards for the widget concept showed two different scenarios. The first one shows Margot, a made-up character, seeing the turtle widget on her phone, and it triggers her to learn more about how her shopping habits affect the environment, see Figure 7.10. The second storyboard for the widget showed a more data visualization-based widget and how it could have the same effect.

The storyboards for the plugin showed how it could work in two different ways. The

first one shows how a carbon emission summary could be included in the check-out when online shopping, and the second one showed the plugin recommending a similar shirt in a second-hand store instead.

The storyboard for the planning concept shows how planning one's emissions and using notifications could work together to make Margot learn about her carbon emissions. All the storyboards can be found in Appendix B.2.

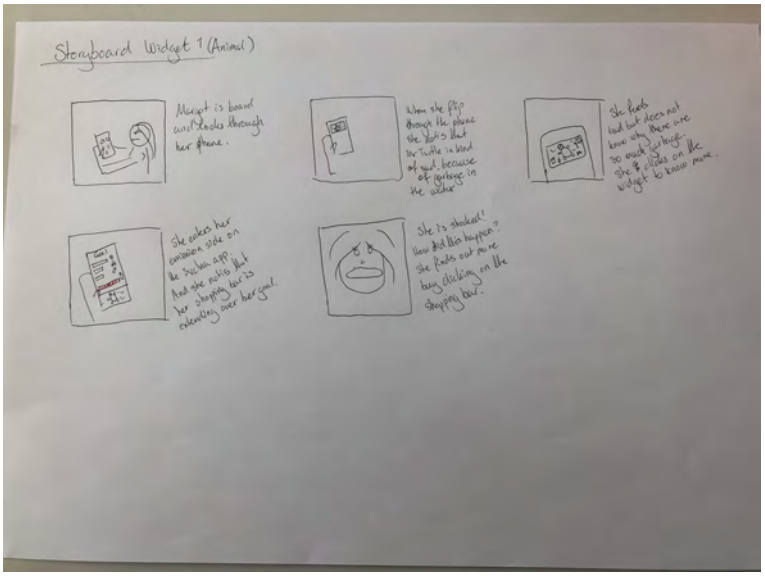

Figure 7.10: A storyboard showing a potential scenario for the widget concept.

7.3 Low-Fidelity Prototyping and Testing

The results from the low-fidelity prototyping will be shown in this section. These results include the wireframes and the paper prototype created, and the testing of both.

7.3.1 Wireframing

Each concept had a wireframe created in Mural. However, the plugin concept had two options showing different alternatives for the functionality, see Figure 7.11. In addition, the wireframe for the planning concept was more integrated with the application than the other concept, allowing the user to pick more specific goals to reach a bigger main goal set in the application. Finally, the widget concept had the same functionality but had several designs to see what a potential user would like the most.

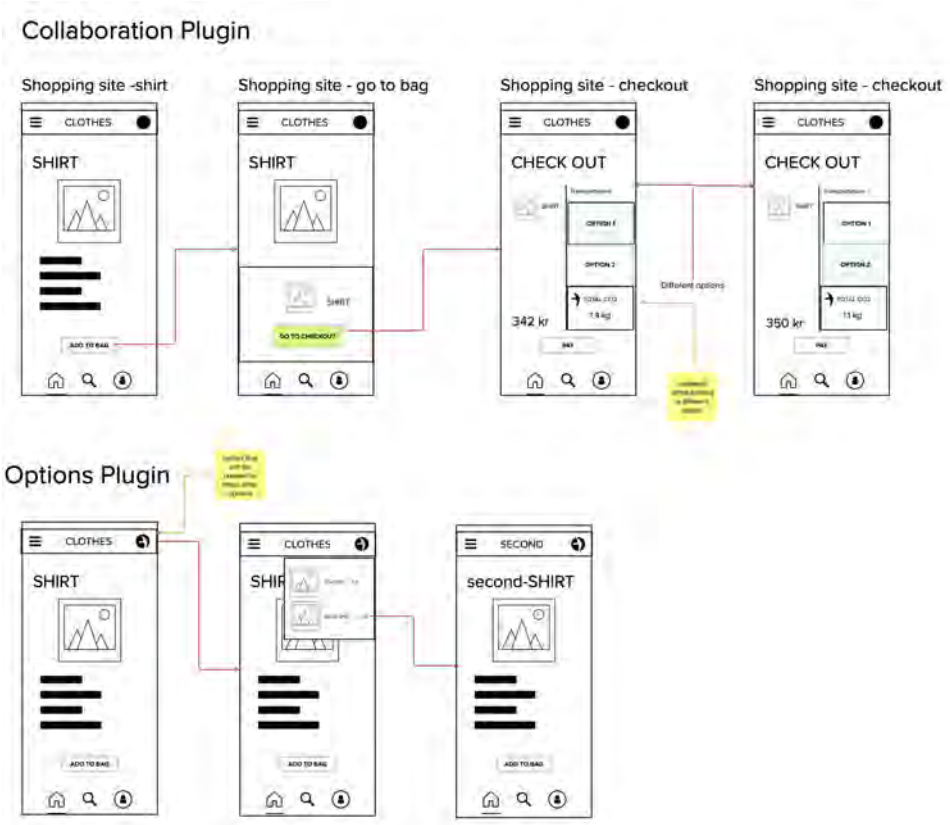

Figure 7.11: The wireframes showing the two different options for the plugin concept.

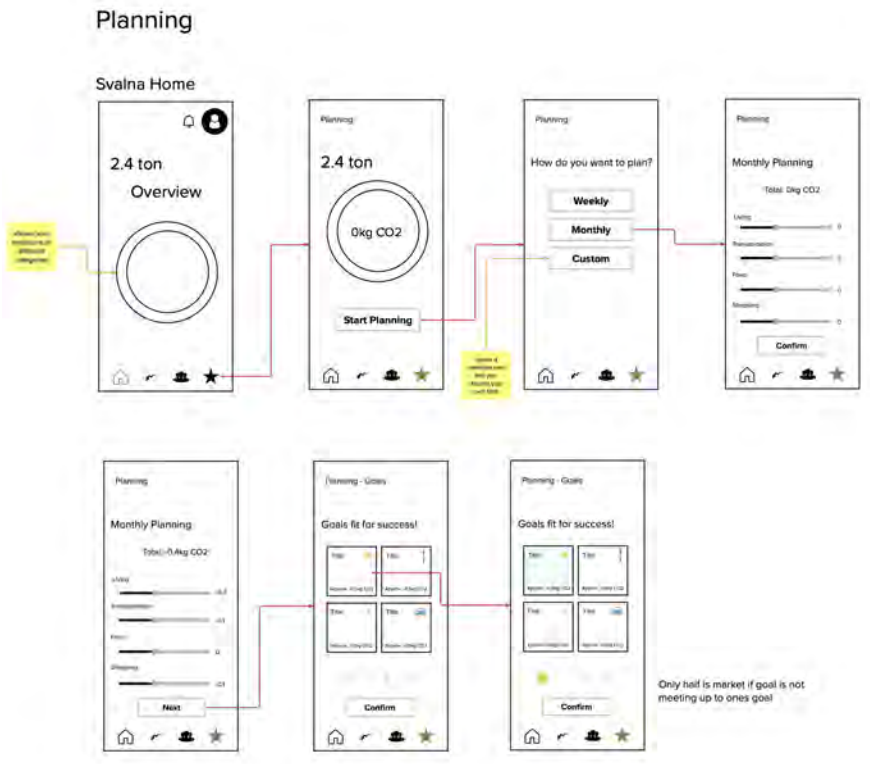

Figure 7.12: The wireframes showing the flow for the planning concept.

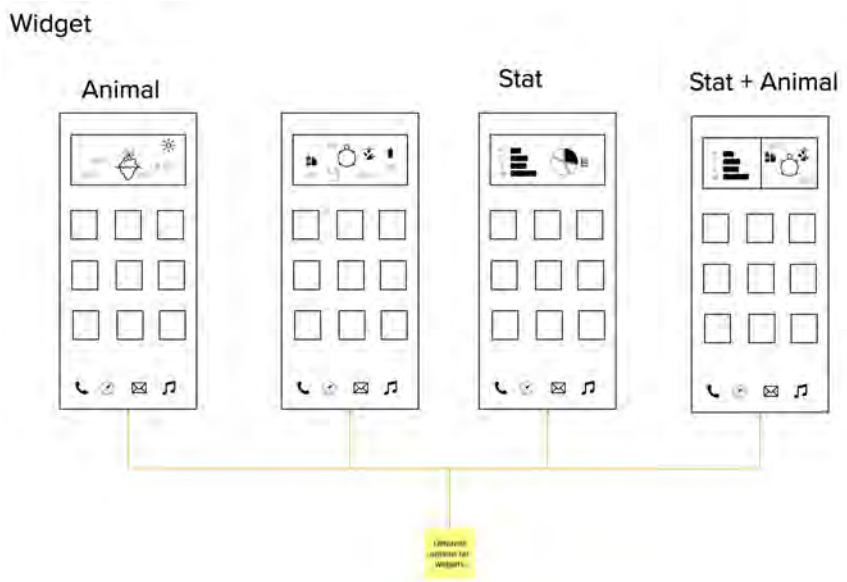

Figure 7.13: The wireframes showing the different options for the widget concept.

7.3.2 Paper Prototype

We created low-fidelity paper prototypes for each concept to later test on participants. We had two different versions of flows for the plugin; one for the alternative suggestion of purchase and total emissions of a buy. Pictures of these can been seen in Figure 7.14 and Figure 7.15. There were two flows for the planning; one was choosing goals before setting the wanted emission, and the other was the opposite. An image of the paper prototype from each of these flows can be seen in Figure 7.16 and 7.17. The widget only had one flow using an animal, a turtle, but the idea of a polar bear was made but never tested. Two images from this flow, the widget, and the monthly overview, can be seen in Figure 7.18 and Figure 7.19. Some of the paper prototype pieces were used in multiple flows.

Figure 7.14: The paper prototype showing the plugin giving suggestions more sustainable options to purchase.

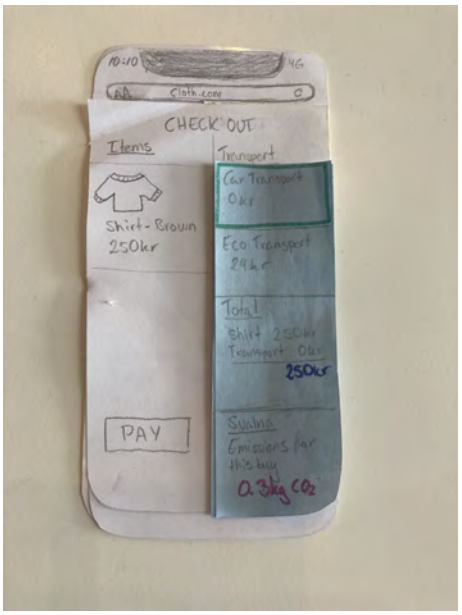

Figure 7.15: The paper prototype showing the plugin giving sustainability information in the checkout of an online store.

Figure 7.16: The paper prototype showing the goals that can be selected by the user.

Figure 7.17: The paper prototype showing the sliders which the users can use to set goals.

Figure 7.18: The paper prototype showing the widget on the home screen of a smartphone.

Figure 7.19: The paper prototype showing the monthly overview of the turtles in the application.

7.3.3 Test of Paper Prototype

The two participants performing the paper prototype test were familiar with the Svalna application due to doing a master thesis there. The testing showed both flaws in the ideas and feedback on the features of the concepts. One topic discussed frequently was the visualizations of the data in the flows and that they were difficult to read and understand, especially negative data concerning emissions. The participants mentioned that it was hard to understand a negative number being a positive outcome, which confused them. Another aspect of data visualization was that they felt they needed to see where users currently are and how they are improving, which was missed when only showing one's goal. Both participants mentioned that the current emissions with the goals could boost one to success.

The response to the different versions of the plugin was mixed. One of the participants was unsure how it would fit with the Svalna application due to their current data and how this would be implemented into their application. However, overall, the participants liked the plugin flow that gave options of similar purchases with a lower emission than the flow that only showed one's emissions information for the purchase.

The flows showing the planning concept were challenging, complex, and difficult to understand for the participants, mainly because of the visualization. Both participants requested more clarity and information about the application's planning and steps.

The widget got a positive response, although the participants were unsure about the concept of using guilt as a way to change people's behavior. It might depend on the animal to choose and the users' views on certain animals. One participant emphasized the importance of keeping the feeling of the widget light and fun to balance the experience when using the widget. There was a discussion on how different animals could be used depending on the type of user's emissions. They also mention the possibility of choosing between having an animal or only having statics with a more realistic comparison for the numbers shown.

7.4 High-Fidelity Prototype and Testing

This section shows the results from the high-fidelity prototyping and testing. These results include the concept mockups and the two iterations of Figma prototypes created during this stage of the design process.

7.4.1 Concept Mockups

The concept mockups consisted of Figma prototypes showing frames of the application interface for the two remaining concepts. The mockups displayed the most critical frames, allowing us to show and evaluate our concepts.

Some colors and design elements used in the mockups were taken from the Svalna application. The colors used included the colors of the different categories (orange for household, green for food, blue for transportation, and pink for shopping) and the buttons. The elements taken included the circles used throughout the application showing emissions in specific categories instead of overall emissions. Keeping the mockups similar to the application ensured that our design fits into the application and felt like a natural extension. Furthermore, the colors used in the application already had their associations and meanings from the Svalna application, which we could benefit from when making our designs. However, these prototypes were still missing some aspects:

1. Certain steps of the flow were missing since more focus was placed on creating the frames to test the feasibility rather than making sure more minor details were included.
2. The prototype was still not interactive and the frames were shown manually.
3. How the widget animal was displayed within the application was left out, as it was a detail we chose to skip at this point.

Several solutions were created to find the best option for how to display data and the visualization of the widget. One aspect we continued working on from both

the workshop and the brainstorming session regarding the widget concept was using animals and showing the emissions of categories. Some animal widgets were also designed with trash surrounding the turtle to symbolize unnecessary emissions. We also created widgets that could be combined with the planning concept and the latest buy feature in the Svalna application. Figure 7.20 shows the different mockups for the widget concept.

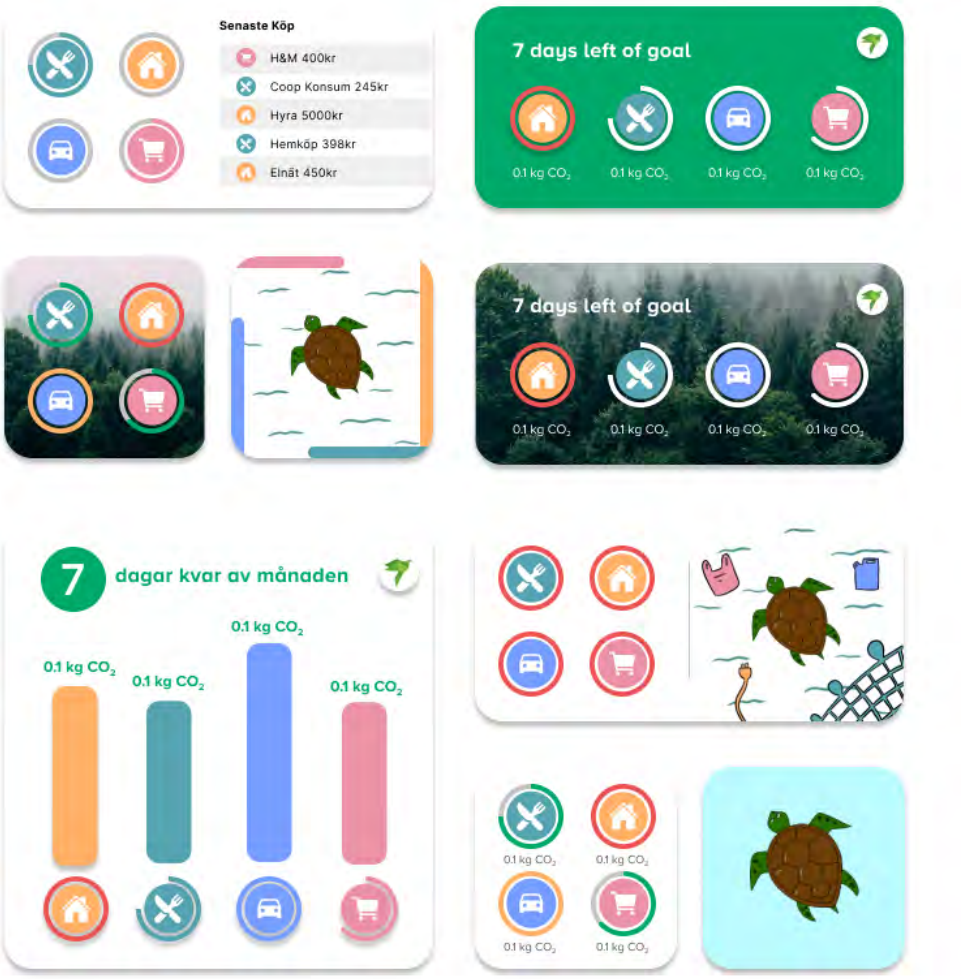

Figure 7.20: A selection of the widget mockups created to test different options.

One challenge for the design was to make the bars work clearly and intuitively in the planning concept. As lower numbers are positive for the environmental cause, it was difficult to communicate this in the design. It is easy to design in a way that triggers users to emit more rather than less, which was not what we intended. We also tried to include information boxes in as many designs as possible since people asked for more comparisons to make the numbers easier to understand. We tried to include several comparisons to make the numbers easier to grasp for all users. Another design element tested in the mockup was overview cards that could be pressed for more information. Figure 7.21 shows the planning concept mockup.

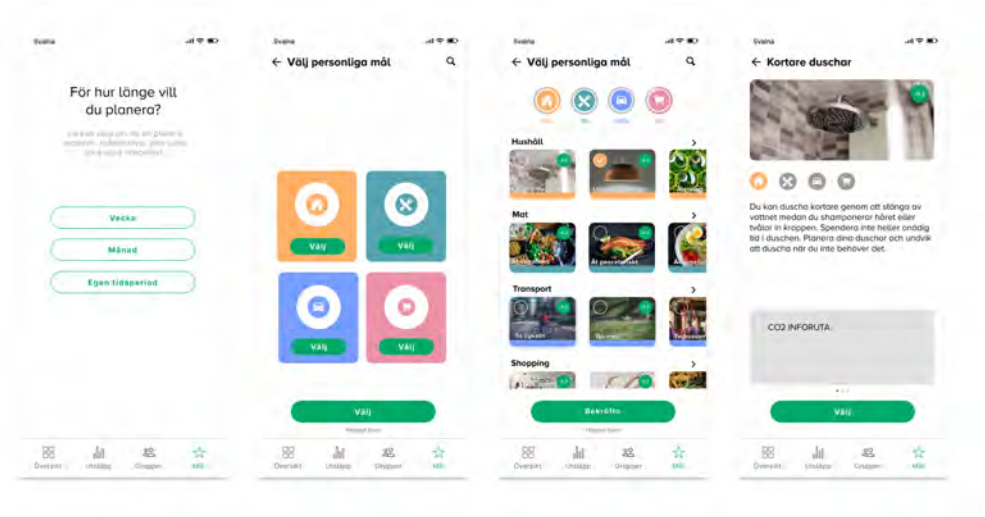

Figure 7.21: A selection of the planning mockups created to test different options.

7.4.2 Testing of Concept Mockups

After showing the concept mockups to Svalna, we got some feedback regarding both of the concepts. We found out that the planning concept was missing some essential details, such that some goals could not be chosen at the same time. An example of this is eating vegan and vegetarian, whose emissions cannot be added to see the total emission since eating vegan already emits less than eating vegetarian.

Svalna liked the option of the planning concept where the goals are chosen first rather than after. They preferred this because deciding how much one wants to lower one's emissions first and then picking goals would be too abstract for most users. We also discussed how to deal with goals that fell into multiple categories and that each goal might have a main category and several subcategories. Overall, Svalna seemed a bit confused by the planning concept but was interested as this was an area of the application that they had tried to improve previously.

As for the widget concept, Svalna was positive. They liked the simplicity of the idea and keeping the feeling light and fun while still dealing with some guilt on the user's end. We discussed how different animals could symbolize different things and how the emissions would affect the animal. They also liked using a widget to show recent purchases and their effect on the user's emissions.

The mockups were also shown to our academic supervisor. He suggested that we keep the concept separated and avoid trying to combine them.

7.4.3 First Iteration High-Fidelity Prototype

We created interactive Figma prototypes for two concepts, one for planning and one for the widget. The planning one has two types of prototypes; one for choosing goals and one for selecting personal goals suggested by the application or goals set by the user. The interactive prototypes were a bit unfinished, meaning that not all elements within the application were connected.

The Svalna application uses tonnes per year when calculating emissions which we first did not realize. We decided to go for kg instead because when looking at things monthly, the numbers became small and felt insignificant and confusing to grasp when using tonnes. In our case, we decided to rework the numbers into kg per month instead to make the number clear.

We decided only to let users select monthly planning for the planning concept rather than having multiple options because it seems most useful when considering salary and paying bills, which occur monthly. The planning prototypes only let the participant select two different goals because of time limitations. Out of these, one goal was the transportation category, and when selected, grayed out the other goals that were not combinable, see Figure 7.22. One of the goals is also clickable for entering a slide with more information about that particular goal. When the goals are selected, the checkmark will be the same color as in the category, and the top bars make it more intuitive for the users to know in which category they have selected a goal and how much. When continuing, the user will end up at the frame *set goals*. Here the user can see the reduction in each category, and the sliders can also be moved if wanting to change more than with the personal goals. The user can also skip the step of personal goals and go directly to the set goals. The sliders show the current emission for each category on the right side. The number above the dot indicates how much has been lowered to the user.

To show data on the emission in the overview, we decided to go for horizontal bars inspired by life bars in games. They start with being filled, and when emissions rise, the bars start to move to the end of the emission goal. Having bars like this might make users want them to be filled because they are running out of life. The personal goals can also be seen here, and the *possible reduction* card shows the total reduction of one selected emission goal. In addition, the card can be slid to the side to view more information on what their lower emission could save, such as m^2 ice. We thought these features would help people feel more motivated to see what effects their changes could have. Figure 7.22 shows the first high-fidelity prototype of the planning concept.

Other colors than the Svalna color palette were added to the prototype. We added a new element that needed a new color that Svalna's limited color palette could not provide. We decided to use a more deep blue color for the background for the turtle. The blue color felt complementary to other Svalna colors and was also visualizing the ocean. The addition of seaweed into the background of the turtle's environment was to avoid making it look empty. The turtle was then added under the emission

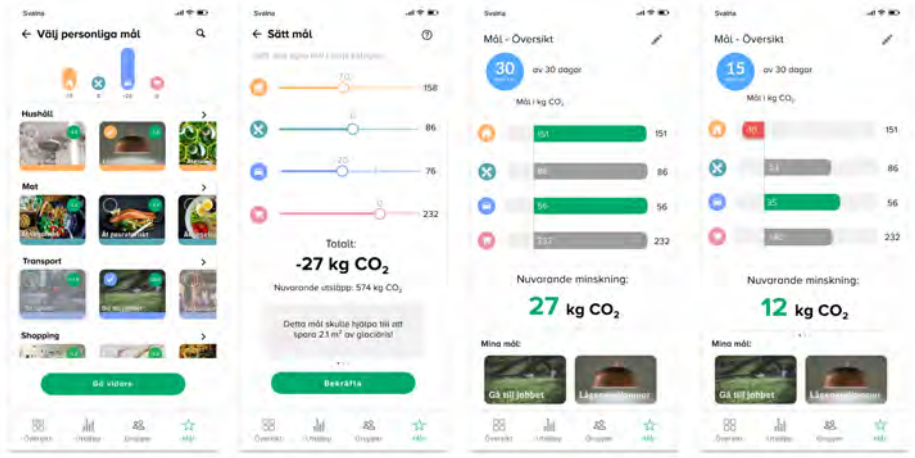

Figure 7.22: First high-fidelity prototype for the planning concept.

tab within the application as a pull-up, see 7.23. The decision then was to stick to having the turtle under the emission tab, but it might be good to have it on its tab later in the design process.

Finally, we designed that the overviews for the widget concept should be clickable to see more information about one's emission for each month. The decision is to have a month, six-month, and year tab because this is a concept Svalna already uses in their application. The cards showing the overviews for these months also needed to be tested further to see if a user would understand them and if the design was clear enough. Figure 7.23 shows the first high-fidelity prototype of the widget concept.

We decided not to continue with the previous buy widget because of the limited time on this project and the complexities of the other planning concepts and the turtle widget.

7.4.4 User Test of First High-Fidelity Prototype

The test of the first high-fidelity prototype was performed on two participants. One participant was interviewed earlier during the testing of the wireframes, and for the other, one was the first time being introduced to the concepts.

The first participant appreciated the clear goals and had no problem navigating the goals and picking them. Things became unclear regarding the sliders; they thought the numbers were confusing. For example, the 0 on the sliders did not make sense, and we need to show better the old value and which one is new. They also struggled with understanding the positive and negative numbers in the overview. For example, -10 seemed like something positive when it was not. Choosing the personal goals was easy, and the participant understood the graying of the goals. Overall, the participant thought positively about the design. As for the widget, the

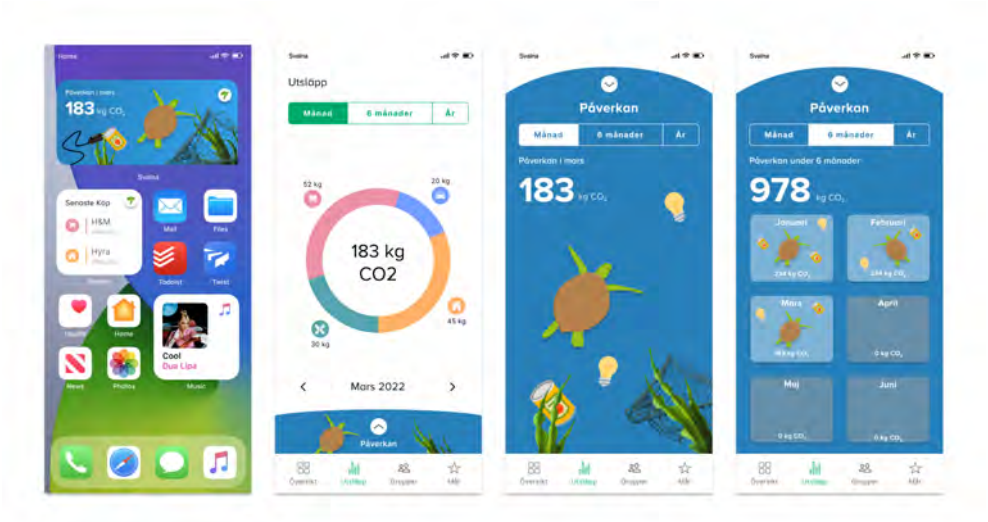

Figure 7.23: First high-fidelity prototype for the widget concept.

main issue was the layout of months and years, which did not feel intuitive. The participant did not think the month in the future should be shown. He also wanted the current month at the top and the other months shown to go backward. The trash that appeared around the turtle was perceived to be unclear. The trash did not demonstrate actual purchases but was instead a symbolization. Maybe it should be better to have a connection to one's purchases or related categories. Aside from that, the design was straightforward. The participant liked the goal concept the most and found it great to be able to pick concrete goals.

The second participant had no problem understanding the section picking goals. When pressing the checkmark on the goal card, the participant accidentally pushed the full card instead. She immediately understood her mistake and went back. Like the first participant, she found the sliders confusing and did not understand the different numbers. She claimed that she found the whole concept of climate and numbers confusing. She said it sounds good to save a certain amount of glacier ice, but still hard to picture how good this was. She blamed this on not previously having encountered climate numbers before. She found the overview to be otherwise clear. The participant had to think before understanding the purpose of the graying out of personal goals. The participant suggested adding the category icons to the goals to make this easier to see. When the time had passed in the test planning prototype, the participant understood the emitted in the housing category had gone over. Still, it was not easy to conceptualize what this meant. It was unclear if it could be fixed or if they had failed the goal indefinitely. Overall, the participant felt optimistic about the concepts and the prototype. There was some trouble navigating the prototype because the test took place on a laptop than a smartphone.

7.4.5 Final Iteration High-Fidelity Prototype

In this final iteration of the high-fidelity prototype, several changes were made. Some changes were very general, like improving the interactivity of the prototype as swiping and scrolling were implemented in Figma. In addition, the language was changed when the user set their own goals, from *goals* to *personal goals* for clarity.

A page that had more changes was the sliders page. Most numbers on the sliders got reworked to be easier to understand after the feedback from the previous testing. The total emissions displayed on the right side of the sliders were changed to show the difference between the last mean and the current goal. The knob now showed the exact value of the slider instead of how much it had been changed.

The overview had changes made to its numbers. The numbers on the right side were removed, and the total was placed inside the bar instead. The numbers were removed to create more consistency with the sliders page and make the bars easier to read. The width of the bars was also adjusted to reflect the look of the rest of the application better. In this new design, once a new plan has been made, the bars start a bit further down, showing that fewer emissions can be emitted than the previous month.

In the previous iteration, the overview displayed a possible amount one would save for one's planning, and this was changed after receiving feedback that it was confusing. The numbers were changed to display the total emission amount one had set for the whole month that, as the month passes, goes down together with the bars. Figure 7.24 shows the changes in the numbers on the slider and the bars and the total emission for a month in the overview. More information was also added to the goals in the overview, showing the emissions and in what category they belong.

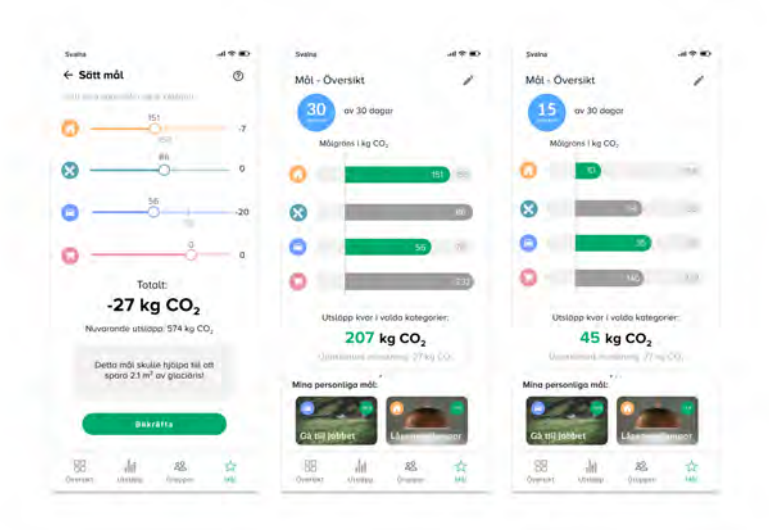

Figure 7.24: The changes made regarding the planning concept in the final iteration.

A significant change in the widget concept was that the trash was removed and reworked into category dots instead. Changing the trash into dots allowed for more information to be displayed and could make it easier to connect certain purchases to the dots and see the purchase category. It was also decided that all purchases should be displayed in the widget, not only the ones deemed harmful or unnecessary.

Another change to the widget concept was changing the monthly and yearly overviews from a grid into a list. The overview was changed to allow for more information to be included and a better overview. We also changed the order of the months displayed, starting with the current month and going back in time. Small up and down arrows were also added to show how the emissions changed month to month. Figure 7.25 shows the final widget concept with the changes of the trash and the overview.

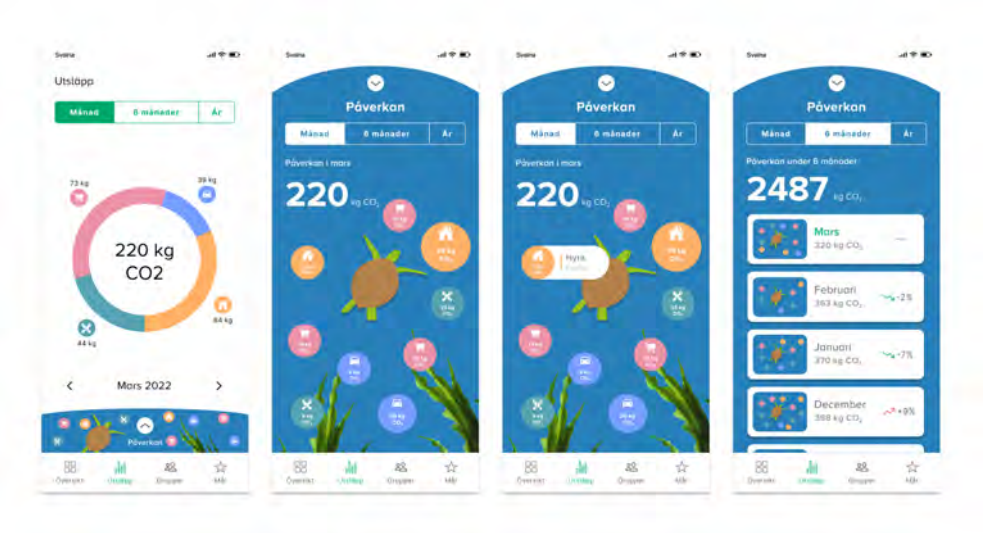

Figure 7.25: The changes made regarding the widget concept in the final iteration.

7.4.6 User Test of Final High-Fidelity Prototype

Four tests were performed and took approximately 30 minutes each. Three participants were students at the same university, whereas one was not. Two of the participants had seen previous project prototypes, and two had not. None had used the actual Svalna application before. Figure 7.26 shows one of the participants performing the test.

As for the planning concept, there were still issues with the data visualization. However, an improvement has been made from the previous test. Most participants struggled with understanding some parts of the data displayed but not as much as before. It was also unclear how to set their own goals and not pick specific ones for all the participants; this could also be due to the test not being clear enough. When asked for opinions, most participants found the concept a great way to learn about sustainable lifestyle changes and their positive effects. They also liked the

pre-made personal goals as they could give inspiration for changes. However, one of the participants struggled more with the parts of the application designed by Svalna and claimed she felt that they made her frustrated.

The widget got a positive response from all participants, all saying that it was their favorite concept of the two. Some participants had difficulty understanding the *påvekan* tab and what it does. There was a discussion of potential name changes to make it more intuitive in that case. The circles seemed to have the same effect as the trash, and all participants understood that it was bad to have too many circles. Not all participants understood that one could press the circles, though, and needed some guidance from the facilitator. One participant wanted the circles to be more individual-looking from each other and suggested making the circles more unique by including the name, category, and emissions directly in all circles. All participants asked what purchases should be included in the widget, and they found it unfair that necessary and reasonable purchases were included alongside the bad and unnecessary ones. They claimed they found this to be discouraging. Overall, one participant expressed interest in including other benefits of sustainable living in the concepts, specifically focusing on saving money from sustainable lifestyle changes. Saving money might increase the interest in the application.

As for the long-term use of the application, the participants found that our concepts are an excellent way to learn about lifestyle and emissions. One participant discussed the application's goal and how it is similar and different from the goal of Svalna. Two participants expressed doubt about how well the application is working and claimed that this could affect how the application is used. All participants claimed that they could imagine using the application every day, week, or month. All thought that they would use the application more initially and less the more they learned about the connections between their lifestyle and emissions.

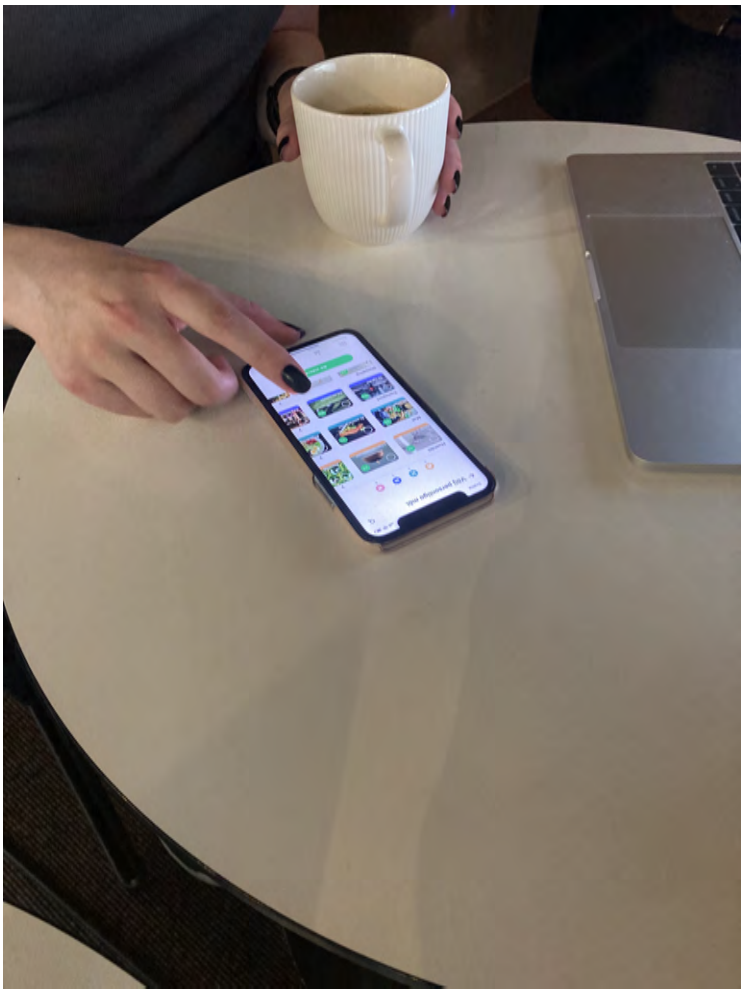

Figure 7.26: A participant performing the final user test on the prototypes.

7.5 Final Concepts and Designs

This section will explain the final concepts thoroughly, utilizing a selection of frames from the final iteration of the prototype.

7.5.1 Planning Concept

This concept allows the user to plan their emissions and set goals. Selected frames from the concept can be seen in Figure 7.27 and Figure 7.28. The concept is located under the goals tab in the application. Looking at Figure 7.27, the first frame, *a*, shows a starting page that tells the user that they can set a goal and plan how to reach it. Frame *b* shows a page of personal goals the user can pick. If a goal is picked, mutually exclusive goals are grayed out. The top bars also reflect how much is planned to be lowered in the specific categories. Frame *c* shows that the user can press a specific category only to see goals in that one category. Finally, frame

d is shown if a goal is pressed and shows more information on the goal and more practical information on how to reach it.

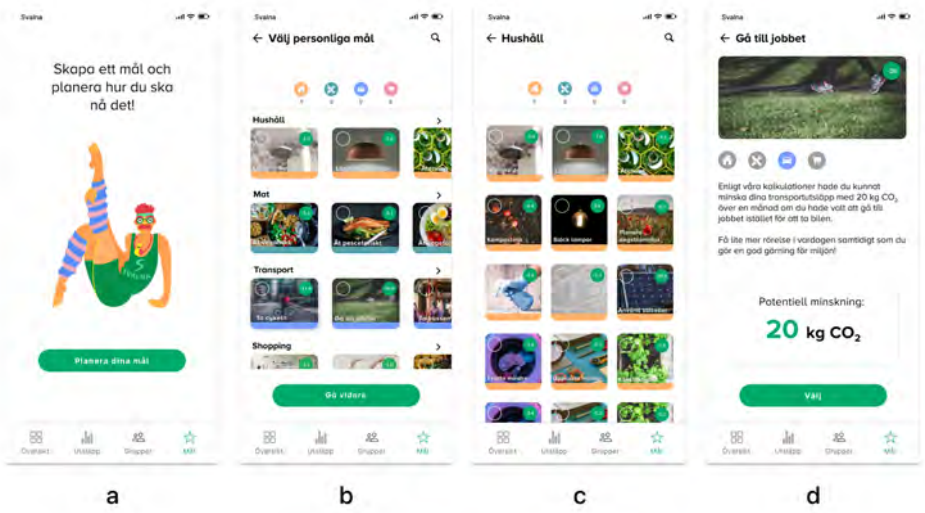

Figure 7.27: A selection of key frames from the planning concept showing where users can select goals and learn more about them.

In Figure 7.28, the next steps of the user flow are shown. First, frame *e* shows the next step after confirming the goals, a set of sliders that the user can change if they want to customize their goals further. Next, frame *f* shows the overview after the goals have been set. This overview is what users would see when checking in on their goals during the month. Finally, frame *g* shows an example of a notification a user could get from the application, and *h* shows how the overview would look if the user entered the application after getting the notification and checked the overview.

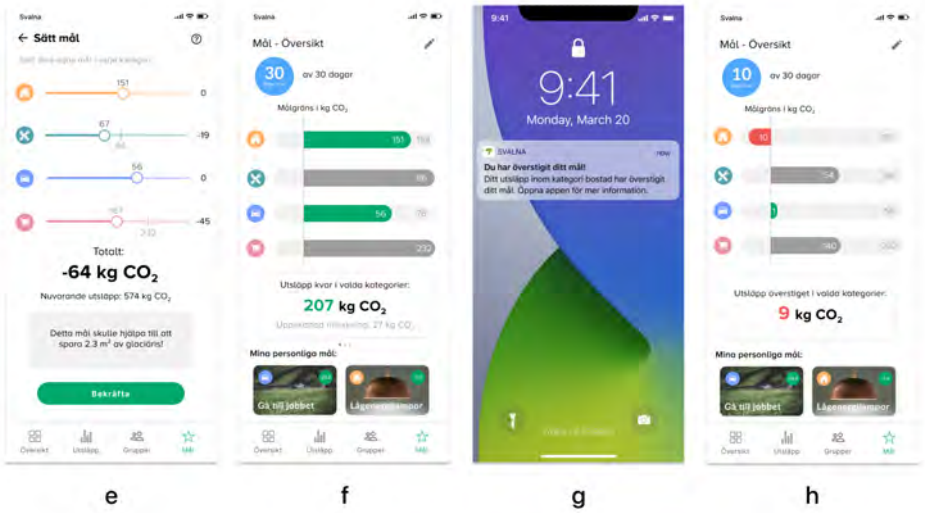

Figure 7.28: A selection key frames from the planning concept showing where users can select goals and learn more about them.

7.5.2 Widget Concept

The widget concept allows the users to place a widget on the home screen of their phone that helps them keep track of their emissions throughout the month. The widget shows a turtle swimming around in the water. When purchases are made, bubbles appear around the turtle, making the space more crowded. The user can enter the application to see more details about their emissions. In Figure 7.29, some of the main frames can be seen at the beginning of a month. Frame *a* shows the widget on the home screen, and frame *b* shows that the user is sent to the emissions tab when pressing the widget. Frame *c* is shown if the user swipes up the påverkan (impact) bar. Frame *d* shows the six-month overview.

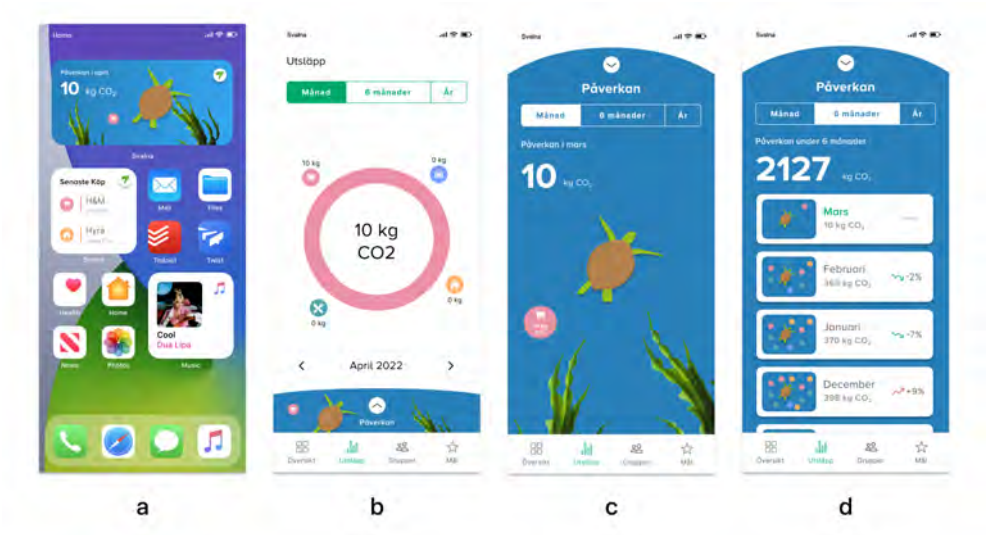

Figure 7.29: Frames from the widget concept at the beginning of the month.

In Figure 7.30, the same frames are shown later in the same month. Frame *e* shows more bubbles in the widget, which is reflected in the number in the emissions tab in frame *f*. When swiping up, see frame *g*, the user can press the bubbles for more information, and frame *h* shows the six-month overview again.

Figure 7.30: Frames from the prototype showing the widget concept later in the month.

8

Discussion

The project aimed to answer the research question:

"*What are important aspects to consider when designing interaction for a carbon calculator while considering long-term use for supporting and influencing users to a more sustainable lifestyle?* "

The project has gone through different phases, using various methods to answer the research question. The discussion will go more in-depth into the result and the design process to analyze different aspects of the project. The discussion will also include recommendations explaining important aspects for creating long-term use within a carbon calculator application. Lastly, a section on future work will explain what steps could be taken to further fill the gap in designing for the long-term use of carbon calculators.

8.1 The Final Results

A recurring discussion during the project was the actual goal of the thesis. One goal was to keep users in the application for a more extended period. However, taking a step back, this was done for the grander goal of promoting sustainable behavior in people long-term. A conflict arises when these goals does not intertwine which then becomes a question of keeping users in an application when the need is no longer there. In this project, the main aim to promote sustainable behaviors long-term and on approaches that could support this goal.

8.1.1 Approaches Explored for Long-Term Use

One approach used to support the long-term use of carbon calculators was emotions, specifically guilt and shame. We received positive feedback from the evaluation participants on using emotions in the concepts. After trying out the two concepts, most participants claimed that their emotions made them want to change into a more pro-environmental behavior. The willingness to participate in pro-environmental behavior was the most evident with the widget concept because of the turtle. Many

participants felt guilty and declared this concept their favorite because of this aspect.

On the other hand, there are several reasons to be critical of this use of emotions. Schwartz and Loewenstein (2017) describe that emotional messages in environmental ads do make people engage in pro-environmental, but fail to engage users long term. Bissing-Olson et al. (2016) claim that emotions can be powerful triggers of behavioral change but that pride, not shame, translates into subsequent pro-environmental action. Overall, the concepts could have had a more significant focus on positive emotions, such as pride, rather than shame and guilt. However, it would be hard to implement this in practice since the pride would have to be focused on sustainable changes. Otherwise, users could become too comfortable with their current lifestyle and not make a change. Making the users not want to engage in more sustainable behaviors would go against the project's goal, as the long-term use of the application would most likely not lead to more sustainable behaviors.

Another approach used to promote long-term use was gamification. We tried to use it sparingly and mainly took inspiration from games in certain aspects of our designs. One example of this was the bars in the planning concept that were designed to shrink when emissions were made. The idea of the bars came from games where one has health or energy bars that slowly run out. This idea was chosen to avoid the feeling of accomplishment when filling the bar to reach a goal. Overall this concept did not translate as well as we had hoped, but it would be interesting to revise it to see if improvements could be made. Overall, the widget concept took more inspiration from the playful feeling of many games. The hope was to balance the serious feeling of the climate crisis and the more playful and fun design to make the concept feel less intimidating. The feedback received from the testing showed that the participants appreciated this playfulness.

Notifications were an approach used to support long-term use. Initially, they were supposed to be more involved in the concepts to see if they could make people use the carbon calculator long-term. In the end, we ran out of time to develop them further. Although, they were included to demonstrate that time had passed by in the planning concept. If we had developed notifications, they would have followed the information we found during the literature study, see Section 3.5.2.

The effectiveness of all of these approaches varies depending on the user's relationship with the environment. For example, Section 3.1 refers to the five different types of attitudes towards the environmental movement described by Theodori and Luloff (2002). Connecting this to the two final concepts, they could probably be more effective to people in the more environmentally concerned groups than those less environmentally concerned ones. The concepts could be good support for the activists, the attentive public, and the sympathetic public since these groups already more or less have an interest in the topic and could benefit from tools helping them to take action. However, there are different needs to consider within these groups. For example, we gave the users the option to set their own goals using sliders in the planning concept, including the expert users or activists using the Svalna application.

On the other hand, the attentive public and the sympathetic public could benefit more from the help of the pre-suggested personal goals. As for the neutrals, an exciting concept could spark an interest, but this is not likely as they do not already have any thoughts or opinions on the climate crisis. It would probably be challenging to get them to use the Svalna application altogether. The group least likely to find interest and change from our concepts would be the opponents. It is worth noting that this group is not the target audience of our designs, though, since we focused on keeping Svalna's users in the application rather than convincing new ones to start using it. Of course, creating solutions to encourage pro-environmental behavior in this group is a relevant part of solving the climate crisis but was considered outside the scope of this project.

As for the long-term use of the concepts, when participants were asked about their perceived long-term use of the two different concepts, most claimed that they could see themselves using the concepts more initially but would get less and less frequent with time. Multiple participants expressed the temporal aspects of the concepts during the testing. They reflected on the experience that they would have over time and how they could develop together with concepts. These reflections supported that the design included aspects of slow interaction to provide a more profound experience. They reflected that using the concepts over a long period would create a valuable experience and better understand how their lifestyle affects the environment. This reflection was interesting to hear as this was something that we were not sure would be apparent to users. Worth noting is that these are speculations on perceived behaviors from the participants and can differ from how they act in reality. The users were never observed using the application over a more extended period, and these answers should be regarded with that in mind.

8.1.2 Long-Term Use and the Final Concepts

Looking at the two concepts closely, the planning concept had several aspects of promoting long-term use. First, it was necessary to consider people's free will to plan around their habits and routines when designing the concept and prototypes. It is challenging to visualize emissions week to week as bills are often paid monthly, and the climate itself is a slow process. Further, it did not make sense to have the emissions for a shorter period because we think that small numbers from a short period would not have the effect as more significant numbers would. The other way around, going for a more extended period than one month would maybe make people forget to log in. Therefore, monthly planning seemed to be the option that made the most sense looking at people's habits and routines and the option most likely to promote long-term use.

It was essential for us to have a variation of personal goals in the planning concept. The variety of goals was to create the planning concept to be more aware of people's needs and abilities, as mentioned in Section 1.4.3. In the prototypes, we came up with several options in each category to choose between and, if implemented, should concern every possible user. We discussed with Svalna during the showing of the

mockups which goals could work for the planning and which could not be combined. Another issue regarding personal goals was if one wanted to plan the next month with a lower emission reduction could make the user feel guilty about it. Users will notice that changing a goal to a lower reduction will worsen the month's total emission. Therefore, they will mostly feel guilty about it and hopefully want to switch to a goal with better emission reduction. Overall, we designed the planning concept to be a tool where one can learn and develop together and, in the end, change one's behavior over time and be aware of one's emissions.

The widget was instead developed to be present all the time for the users, that it could be a daily habit to check one's emission and at the same time have the freedom to decide when. It was further developed during the design process for the user to see emissions changes and updates without thinking about it. During the interview in the empathize phase, we got feedback that people are not using a widget that much, which made us first think about not developing one. What changed was that it could be an extent of the carbon calculator application, and we wanted people to be able to interact with it and not only see numbers that were hard to grasp. An essential aspect of the widget is that it does not necessarily promote more application use. It would keep people up to date with their emissions and remind them of the existence of the Svalna application daily, but this does not always translate into application use. If the goal is to make people more environmentally aware, this does not have to be a problem. However, if the goal is to make more people interact with the application, this could be an issue.

8.1.3 The Use of Animals in the Widget

Another essential aspect of the widget is the use of animals. It initially came from the two workshops. Afterward, we noticed that this could be because of the icebreaker at the beginning of the workshop that involved one drawing one's favorite animal. One idea could have been to change the icebreaker for the second workshop with Svalna to see if the outcome would have been different or to have a third workshop to limit the possibility that the participant thought about animals during the first exercise. However, of the two groups we had during the student workshop, only one group used the idea of an animal. They drew different animals between the students and Svalna, but both animals, the turtle and chicken are often associated with guilt regarding animal well-being. Maybe the animals were a way for them put these feelings into a tangible concept and think about what would make them care more about the climate and how it could change their behavior.

Another aspect of the animal is that it could exist and interact within the application. People could still use the feature, but they could decide if they wanted to keep more up-to-date with their emissions using the widget. Another thought was to design more animals that people could choose, but they had to be removed from the process due to limited time.

8.1.4 Information Displayed in the Concepts

Each of the concepts included information and numbers about climate emissions. The information and numbers used in our prototype are fictional and have no scientific background; their primary purpose was for the users to get a visualization of the emission numbers to see them differently. For example, how much ice could be saved each month when lowering one's emissions. It is essential to consider if to be used in carbon calculators that this information and numbers are correct and transparent to the users. We believe that having transparency will make people search for more information regarding the climate to gain new knowledge about the topic. If not done correctly, this could lead to filter bubbles, see Section 1.4.4, because how they obtain this information would be unknown to the user and can lead them to only relying on one type of source.

8.2 The Design Process

Having the Hasso-Plattner Design Thinking Model as a basis for our design process helped us structure the work quickly and productively. We prefer the use of the phases in that model as opposed to the others mentioned, and that it fits with what we wanted to do regarding everything from the collection of data to the prototyping phase. The design process was also structured to be iterative, which gave us the freedom to go back to another phase to find new information that we thought had been missed or when a new question came up. The process also used Research Through Design by looking at previous design processes from master thesis projects and design solutions to implement into our design. Due to limited times, we had wished for more iterations and a more extended test period in our design process to prove that our concept could work for long-term use in a carbon calculator application.

8.2.1 The Phases and Methods

The participants participating in data collection and testing lacked diversity. A good idea could be to collect broader data and thoughts from the testing by searching for other people. That might have changed the outcome of the final design or could support it better. At the same time, we felt that we got enough qualitative data from the participants to move on.

The workshops were for us to make people outside of the project contribute ideas into what could support long-term use for a carbon calculator application and to avoid designing only for ourselves. The workshop allowed participants to think creatively and go outside the box. The discussion at the end of each exercise was to boost new ideas. We felt that this worked out very well, and we got ideas that we had not discussed before, and what was gained from the workshop was also considered throughout the design process.

When designing concepts for long-term use, we set up different scenarios during the process to find out the appropriate use frequency for a carbon calculator application regarding cultural activities and local ecologies, see Section 3.3.2. Before setting the scenarios, it was essential to collect data from potential users on their thoughts about when and how often they would like information regarding their emissions. This step was critical at the beginning of the design process to consider the users' daily routines and needs so the concepts would be designed to avoid being annoying or interruptive for the users. The interviews also gave information about their application use. Could we find applications they frequently use, daily, weekly and monthly? How are these applications made to support long-term use, and where would a carbon calculator fit? The scenarios were developed using storyboarding with the different people's routines in mind when they want to use and receive feedback from a carbon calculator. Each person's habits differ, so in our design process, we thought about making concepts that hopefully could be integrated into everyone's routines to broaden the use of the carbon calculator application.

The climate is a slow process with its own long-term goal; see Section 3.4. Designing for users with a topic that is not noticeable in the short term was challenging. That was why we always interviewed participants after each testing, and this was not only to have the users in mind. It ensured that the users got the right and necessary information they needed to avoid irritation and confusion that otherwise could make people stop using a carbon calculator. The climate is itself a complex topic even for us researching and designing for it. We constantly questioned if the concept supported long-term behavior change to slow down climate change. When people do not see a change in front of them in real life as the climate does, will numbers together with visualization concepts fill that gap while keeping people interacting with it and changing for the better? It was not relevant in the project to give the correct numbers. Still, it would have been preferred if another iteration could have been made with actual numbers and tested over a month, and then have an interview with participants regarding their emotions. Did the concepts make them change behavior, did they get the help they needed to reach their emission goal, and would they use the application long-term?

8.2.2 The Methods of Testing

We tested ideas regarding motivation in the design early on in the process. Using the methods of wireframes and mockups, we could get feedback on each idea and if something was missing or wrong. The mockups helped limit design ideas for each concept, and it was like a design brainstorming for us. The prototyping throughout the process made it possible to test the intrinsic and extrinsic motivations of the design. By having these motivation concepts in mind during the process, we could develop and test what makes people use them for fun and what rewards could be gained to use the concepts. The development of the concept was mainly focused on individual motivation by trying to avoid pinning people against each other or hindering people from changing behavior because they are below or far over average.

They might stop using the application because they are either better than others or are so far from reaching a lower goal that it feels hopeless. However, the concept could have been developed into working in a social setting to gain rewards. However, we wanted to avoid rewards such as gift cards because it is hard to do it in a climate-friendly way.

The tests made for the project were only tested for a short time, meaning that we could not test the prototypes for a longer time. We do think that the test we conducted, together with the interview questions, answered if people thought they would use it and if it supported the idea of using a carbon calculator long-term. The process involved the aspect of slow technology, see Section 3.3.1, to prove that what we were creating could be turned into a concept that would work for users long-term. We wanted to design beyond guilt, which has been shown to work for long-term use, by making the concepts playful and encouraging curiosity into people's emissions that could support and be integrated into the users' daily routines. The user is developed and changing together with the concepts, creating a slow interaction that makes it work long-term.

8.3 Recommendations for Designing Long-Term Use in Carbon Calculators

This section contains important aspects to consider when designing for the long-term use of carbon calculators in the form of recommendations. The recommendations were discovered throughout the thesis project, from the literature study, theory, design process, and results. They could be a basis for other designers who want to create carbon calculators suitable for long-term use.

- **Reflect on the ethics.** Keeping users in an application that does not benefit them can easily become ethically questionable. This issue can be avoided by always focusing on the bigger goal of promoting sustainable habits. The topic of ethics was researched during the beginning of the project during our literature study and continuously discussed when creating the concepts.
- **Select a target audience.** Consider the users you are designing for early on in the process. For example, convincing a skeptic might differ from supporting someone already engaged in the climate cause. Different attitudes toward the environment were researched during the literature study and helped us to define and narrow down the project.
- **Remember the bigger goal of long-term use.** The application should have a clear focus on the goal regarding the long-term use for its user. Furthermore, think about how to support the user to reach a desired sustainable lifestyle. We learned this from the participants in the emphasize phase, and it was essential when ideating and developing the concepts to ensure they supported the users.

- **Define the long-term.** Think about slow interaction for sustaining long-term use by specifying daily, weekly or monthly use. Also, consider for how long this use should continue as the goal of long-term use can be indefinite, or until a certain goal is reached. Defining this can support the design choices made during the process. Long-term aspects was researched early on in the process, and when prototyping, the differences between types of long-term became apparent in regards in climate change and application use.

- **Keep emotions balanced.** Do not be afraid to make users feel negative feelings, such as guilt or shame. However, balancing these feelings with equally positive ones, like pride, is important. Emotions were researched initially and were brought up again in the workshops by the participants. We found emotions to be important to promote long-term engagement which later showed in our prototype testing.

- **Compare people wisely.** Social comparison can be beneficial, but it can have some drawbacks. For example, if people feel far worse than others, they might feel discouraged to change. The other way around, people with fewer emissions might not feel like they must change. Although social comparison seemed to be useful during our research, during the initial interviews and later testing, we found that users seemed to be critical of the idea and feel discouraged by the concept of being compared to each other.

- **Be careful with rewards when using gamification.** Avoid focusing on extrinsic motivation rewards such as coupons and prices. These can lead to consumption and generate emissions. Instead, focus on intrinsic rewards and motivation. Several concepts using extrinsic motivations were considered early in the design process but discarded as they went against the bigger goal of sustainability.

- **Acknowledge the long-term experience.** An experience can evolve and be perceived differently over time. Consider the temporality of the design and how it can be used to strengthen the experience for the users. The temporal aspect became apparent during the testing of the concepts. It was a central part of the development because it was important to know that the experience could change over time and use this to our benefit.

- **Aim to make the climate understandable.** For ordinary people, climate data can be challenging to comprehend due to the complexity of emission numbers. Try to visualize, explain, and compare to relatable everyday topics to make the numbers understandable. Making a concept understandable was brought up by users in the empathize phase, and we understood that understanding a concept is necessary to feel empowered to change. When this was later added into the prototypes and tested, the feedback on the participants supported this.

- **Prioritize long-term testing.** An excellent way to examine if an idea or concept would work long-term is to test it long-term. An extended testing

period takes preparation and planning, and if deemed worth it, it needs to be prioritized in the design process. We wish we could have included this in the project as this would be an important part of validating the concepts, as this is supported by research.

8.4 Future Work

This project has worked to fill the gap in design solutions to promote the long-term use of carbon calculators. As it is a complex topic, more time and further work would have to fill the gap solidly. The project would, first of all, need a test of the concepts individually for a more extended period to support the design concepts. Continuously working iteratively to solve issues in the current designs and allowing for a more extended test period would be essential to determine if and how effective these concepts are long-term. These future tests need to be on a larger group of participants and account for factors such as age, gender, income, and location to better understand for what people the concepts would be influential, as mentioned in Section 3.1.

The concepts would also have to be integrated and implemented into the Svalna application to conduct these tests. Doing this would allow for testing the concepts within the actual context of use and not only separately from the application. Implementing the concepts into the application could also allow for real numbers to be used, revealing information on how understandable these numbers are to users. One method we would have liked to try and could have been beneficial for the project would have been A/B Testing (Martin & Hanington, 2012, pp.8). Here one could have tested two versions of the application; one is how the application is currently designed, and the other is the new design with the included concepts.

If more time was available, other approaches could be explored compared to the current concepts. One approach showing great results for long-term use is *nudging* regarding the climate (Byerly et al., 2018). If this approach had been included in the design process and the design could have been designed differently from the design we created today, or if it could have helped us solve questions we could not answer. We did think about nudging when we started our design process, but we felt that we already had many approaches to investigate, and nudging happens to be left out of the selected ones.

Lastly, the recommendations of important aspects given could benefit from being validated by being used when designing a carbon calculator application separate from the Svalna application. Although other calculators were researched and considered, the concepts and recommendations were developed with the Svalna application as a base. Validating these on another calculator could solidify that these recommendations generally work for carbon calculator applications and further fill the gap.

9

Conclusion

The project aimed to answer the research question:

"*What are important aspects to consider when designing interaction for a carbon calculator while considering long-term use for supporting and influencing users to a more sustainable lifestyle?* "

We used an iterative design process inspired by the Hasso-Plattner Design Thinking model to answer our research question. Using an iterative process through the project made it easy for us to go back and change aspects that needed more refined research or another approach. The project used Research Through Design and the process of designing to answer the research question. It is also used to research the selected topic and find methods and designs to use in our process and design.

The final results of the high-fidelity prototypes consisted of two separate concepts. The first one was a planning concept with the possibility of choosing personal goals or setting individual ones in each category to reduce the emission produced each month. The planning concept gave the individual user the freedom to develop their plan to limit their emissions at their own pace. It can also be used to stay on track with one's emissions and, in the end, allow the users to learn how to live a more sustainable lifestyle. The second concept was a turtle widget, designed to be a playful way to see one's emissions. The turtle also plays on the feelings of guilt that one's actions will affect the climate. The more one lets out; the more emission bubbles will appear around the turtle, making the sea environment crowded. The turtle concept within the application is also interactive in that it is possible to view one's emissions through the bubbles.

Through creating these concepts, a list of important aspects to consider in the form of recommendations was created. These ten recommendations included;

- Reflect on the ethics.
- Select a target audience.
- Remember the bigger goal of long-term use.
- Define the long-term.
- Keep emotions balanced.

- Compare people wisely.
- Be careful with rewards when using gamification.
- Acknowledge the long-term experience.
- Aim to make the climate understandable.
- Prioritize long-term testing.

Overall, the thesis aimed to fill the gap in design solutions to promote the long-term use of carbon calculators. It has provided two concepts with the potential to improve long-term use and provided a list of aspects to consider for other designers who want to explore the same challenge in the future. However, the thesis results are limited, mainly because of the absence of long-term testing and the lack of diversity among the test participants. More extensive and extended testing would have to be performed to guarantee that the concepts would work long-term.

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A

Appendix - Starbursting Questions and Answers

Plugin

Who?

- Who is the target audience?
    - People who are interested in sustainability
    - People who shop online
    - People who want to explore new and more sustainable options
- Who are the stakeholders?
    - Svalna
    - Users of the Svalna app
    - Online stores
    - Payment systems/banks
    - Transportation companies
- Who are our competitors?
    - Klarna
- Who do we want to collaborate with?
    - Online stores
    - Transportation companies
    - Or no one

What?

- What should we call it?
    - Plugin for sustainable shopping
    - Plugin to track online shopping emissions
- What are the intended features?
    - Information about the emissions of a purchase
        - Also see returns
    - See different transportation options and their emissions in real time
    - Shows up in the shopping bag or at checkout
    - Overview of previous purchases on website
    - Overview of previous purchases in app
    - Overview of how transportation will be (multiple packages, from where, how)
    - Overview of the whole purchase
- What is essential?
    - A sustainability overview when making an online purchase
    - Seeing an overview of multiple purchases in the app
- What will the effect be?
    - People shopping less
    - People making more sustainable choices when online shopping
- What time of the day to use it?
    - All
    - Every time they shop
- What is the design going to look like?

    - Simple
    - Matches Svalna's look
    - Discrete but visible
- What are the limitations of this idea?
    - Technical limitations
    - Only for online purchases
    - Others companies collaboration is needed

How?

- How can this lower people's emissions?
    - Make them consider their purchases
    - Make them shop less
    - Make them choose more sustainable options for products and transportation while shopping
    - Make people more aware of their shopping habits
- How does this improve the long-term use of the app?
    - It makes Svalna into more of a tool
    - It shows up with no effort, people don't have to commit to open the app
- How can this make people interested in the climate?
    - It makes the information more visible and reachable
    - Easier to understand and feel like you can make a difference
- How will users find out about it?
    - Through the app (notification, announcement)
    - Through collaborations
- How will this promote sustainability?
    - If people buy less it is good for the environment
    - Could promote more sustainable transportation options
    - Could promote more green online shopping and make companies want to invest in it
- How will people use it?
    - A plugin in their browser
    - Through collaboration within other apps
- How will it interact with the rest of the app?
    - Check the app to see an overview
    - App gives feedback if you shop a lot
    - Check app to see more details
- How will it interact with other websites?
    - Collaboration might be needed to add the plugin
    - Shows up and links to the Svalna app

Where?

- Where will people use it?
    - On online stores or apps
- Where should it be?
    - As a plugin that shows up at checkout
    - As a notification when you browse an online store
- Where can people find this?
    - Through Svalna
    - Through collaborations with other companies
- Where should it be used?
    - Within the smartphone

When?

- When is it suitable to use it?
    - When you want to buy something
- When should it be used?
    - When you buy something online
    - When looking for different options when you want to buy something online
- When will people use it?
    - When they buy something online or through an app
- When shouldn't it be used?
    - When using your laptop to buy something
    - When it's not relevant

Why?

- Why should people use this, according to us?
    - Because we want them to be better for the environment
    - Because we want them to interact with the Svalna app more
    - We want the app to be a natural part of their shopping experience
    - We want people to reflect on what they buy
- Why is this useful to Svalna?
    - People would use their app more
    - Their app would have a larger impact on people's lives
    - Could create new connections to other companies
    - A new concept, innovative
    - people can't hide some of their emissions regarding online purchases.
- Why would people be interested in this?
    - A new concept, fun to try
    - More transparency
    - Help them make better choices
    - More directions on how to make good choices
    - Others recommendations
- Why should people use this to lower their emissions?
    - It's good for the environment
    - They could consume less

    - A way of making something they already do better for the environment
    - More transparent about their habits and choices
- Why is it a good time for this product?
    - People are interested in doing better for the environment
    - A lot of people buy things online nowadays
    - People want more transparency
- Why will this make Svalna a more attractive app?
    - More focus on making good choices before they are made rather than being shamed after
    - Looks innovative
    - More people

Widget

Who?

- Who is the target audience?
    - People who want to live more sustainably
    - People who want to make sustainability more fun and lighthearted
    - People who want to keep up to date on their carbon footprint
- Who are the stakeholders?
    - Svalna
    - Svalna's users
- Who are our competitors?
    - Other widgets that take up the screen
    - Other climate-related apps with widgets
- Who do we want to collaborate with?
    - None that we can think of

What?

- What should we call it?
    - Widget visualization
    - Widget pet
    - Widget overview
- What are the intended features?
    - Overview on information in real time
    - Easy to open the app through the widget
    - Looks good/cute, fun to look at but not annoying
    - Playful
    - Emotional
- What is essential?
    - Show the information in real time
    - Easy to understand
    - Three different sizes

- What will the effect be?
    - People are more updated on their emissions, not as surprising when you open the app
    - People will the topic more fun and playful, not as stressful
    - More likely to actually open the app to find out more
- What time of the day to use it?
    - When you open your phone to scroll a bit
    - Quickly, many times a day
- What is the design going to look like?
    - Cute, fun, playful
    - Simple
    - Same color scheme as Svalna

How?

- How can this lower people's emissions?
    - Make the app feel less intimidating
    - Make people keep track of their emissions in an easy way
    - Keeps you updated and might affect people's decisions
- How does this improve the long-term use of the app?
    - Hopefully. People see the widget and get reminded.
    - They might want to check the app for more details or help to improve their "widget".
- How can this make people interested in the climate?
    - Make it more visual and fun
    - Less scary than having to commit to opening the app
- How will users find out about it?
    - Announcement in Svalna app
- How will this promote sustainability?
    - People are more updated on their emissions and feel more empowered to change it
- How will people use it?
    - More in the background, but also very visible
    - An easy way to keep up to date without having to look at exact numbers
- How will it interact with the rest of the app?
    - Clicking the widget will link to the app
    - The visualization can also be found in the app somehow
- How will it interact with other websites?
    - It won't

Where?

- Where will people use it?
    - On their smartphone
    - On the display, home screen
- Where should it be?
    - On a spot on the home screen chosen by the user

- Where can people find this?
    - Phone display
- Where should it be used?
    - Phone display, decided by the user

When?

- When is it suitable to use it?
    - All the time
    - Not much interaction
- When should it be used?
    - Just passing by
    - Does not take much focus
    - A way to get to the Svalna app easily
- When will people use it?
    - To get a quick look
- When shouldn't it be used?
    - When being really focused on something else

Why?

- Why should people use this?
    - FUN
    - Quick look, easy to get updated on your status
    - Good way to get reminded to do your best
- Why is this useful to Svalna?
    - Makes their app feel less intimidating and more fun
    - People might want to understand the widget and enters the app for more information
- Why would people be interested in this?
    - To keep updated without anxiety and pressure
    - Relevant information easily obtained
    - Instincts to care for things
    - + something cute or good looking on their screens
- Why should people use this to lower their emissions?
    - Good tool to stay updated on your progress without a lot of commitment
- Why is it a good time for this product?
    - People want to make a change, but feel confused and intimidated
    - People want to understand how choices affect the environment, but lack information about it. Immediate feedback.
- Why will this make Svalna a more attractive app?
    - Can become a more helpful (but still fun) tool to understand the consequences of your actions

Planning and Commitments

Who?

- Who is the target audience?
    - People who want to plan beforehand
    - People who want to lower their emissions
- Who are the stakeholders?
    - Svalna
    - Svalna's users
    - Could collaborate with other companies
- Who are our competitors?
    - Other apps that allows you to plan
    - Things lite klimatsmart semester that makes you plan for climate
- Who do we want to collaborate with?
    - More niche planning tools, ex. for travel or food

What?

- What should we call it?
    - Commitments
    - Commitments within categories
    - Plan to lower your emissions
- What are the intended features?
    - Plan within different categories
    - Set goals/commitments
    - Get updates on how it's going through notifications
    - Customize notifications
    - Suggestions on changes to make to reach your goals
- What is essential?
    - Get goals within categories
    - See your progress beforehand
- What will the effect be?
    - People being able to commit to things beforehand
    - People understanding better what to do to improve
- What time of the day to use it?
    - Planning: if you have a moment for it, beginning of month or week
    - Notifications: when it fits the user, should not take much time
- What is the design going to look like?
    - Match Svalna app
    - In the app

How?

- How can this lower people's emissions?
    - Make them think before they act
    - Keep them motivated and up to date
- How does this improve the long-term use of the app?
    - You must use the app to plan or to check more details on your progress
    - Commitments are for a limited time, more interest in checking up on your score during that time
- How can this make people interested in the climate?
    - Make them feel more empowered to make a change
    - Easier to plan for a change
- How will users find out about it?
    - Though the app
- How will this promote sustainability?
    - People can make good choices beforehand and set themselves up for success
    - Changes can be made over time and make a more permanent result
- How will people use it?
    - In the beginning or a week or month
    - Through the Svalna app
- How will it interact with the rest of the app?
    - Its own tab, or as a part of the goals
- How will it interact with other websites?
    - No

Where?

- Where will people use it?
    - In the app
    - Anywhere
    - In the beginning of a week or month, and then to check up on the progress
- Where should it be?
    - In the app
- Where can people find this?
    - In the app
- Where should it be used?
    - In the app

When?

- When is it suitable to use it?
    - In the beginning of week or month, or when it fits them
- When should it be used?
    - Every day of the week
- When will people use it?
    - Probably in the beginning
- When shouldn't it be used?

    - Avoid in the middle of the week

Why?

- Why should people use this?
    - To get an easier overview
    - Makes them feel accountable
    - Easier to make a plan and succeed with it
- Why is this useful to Svalna?
    - Makes their app into more of a tool which could make people use it more
- Why would people be interested in this?
    - A good way to actually make a change
- Why should people use this to lower their emissions?
    - Because they don't have to learn from their mistakes, they can make it right immediately
- Why is it a good time for this product?
    - People want to do better
    - People want to get a better understanding of how their choices affect the environment
- Why will this make Svalna a more attractive app?
    - More useful

B

Appendix - Ideation Sketches

B.1 Sketches of Concepts

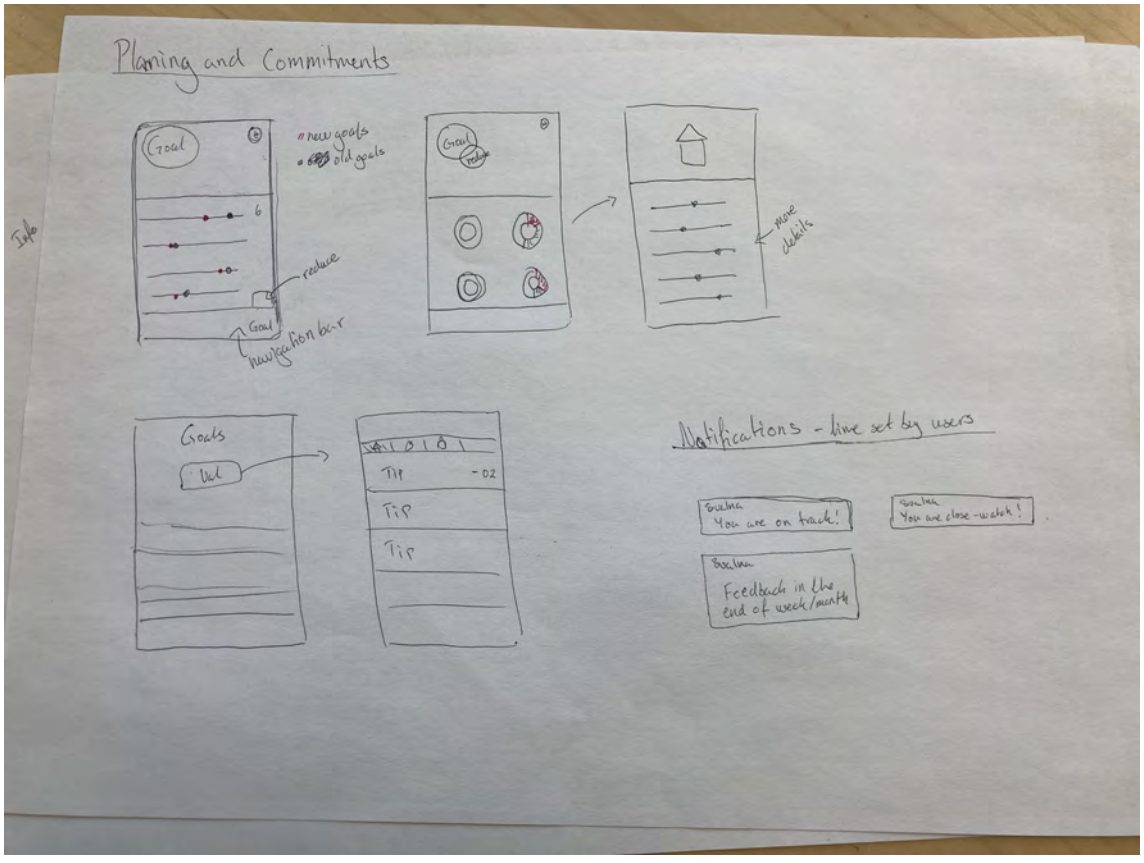

Figure B.1: Sketches showing screens from the planning concept.

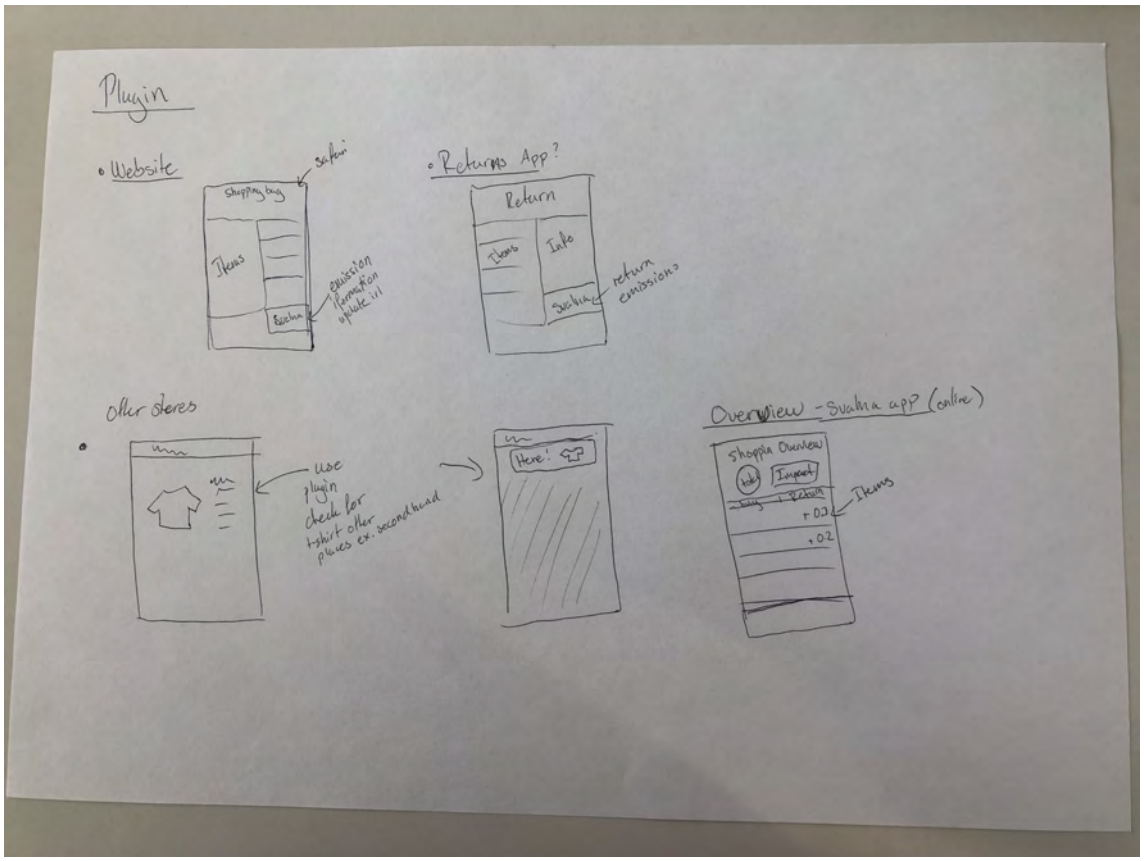

Figure B.2: Sketches showing screens from one version of the plugin concept.

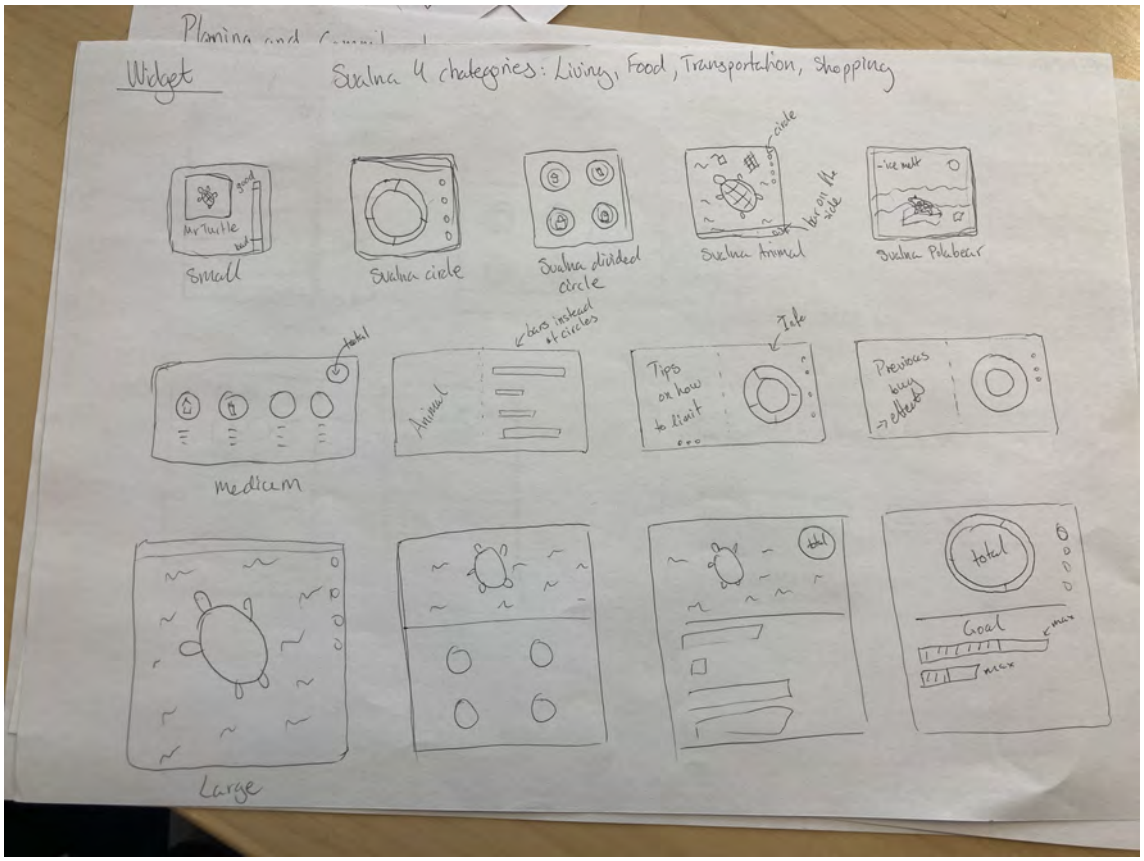

Figure B.3: Sketches showing variations of widgets for the widget concept.

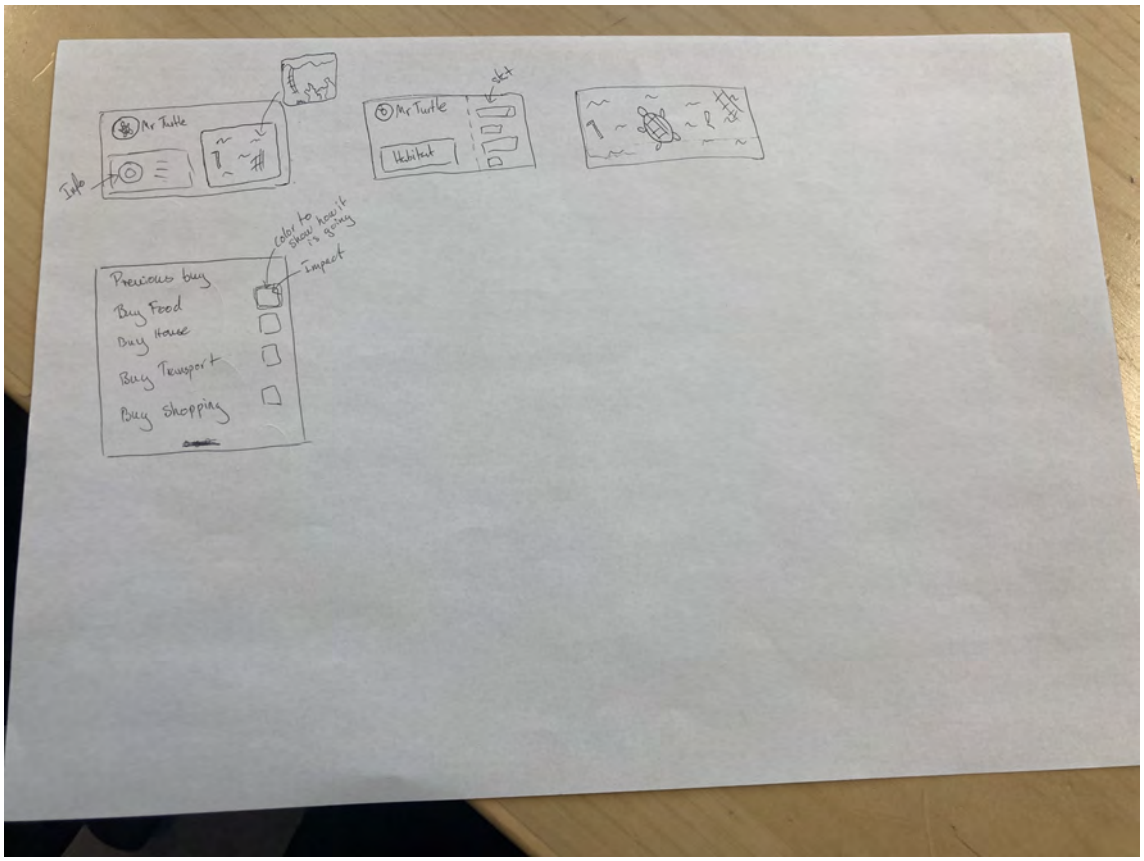

Figure B.4: More sketches showing widgets for the widget concepts.

B.2 Concept Storyboards

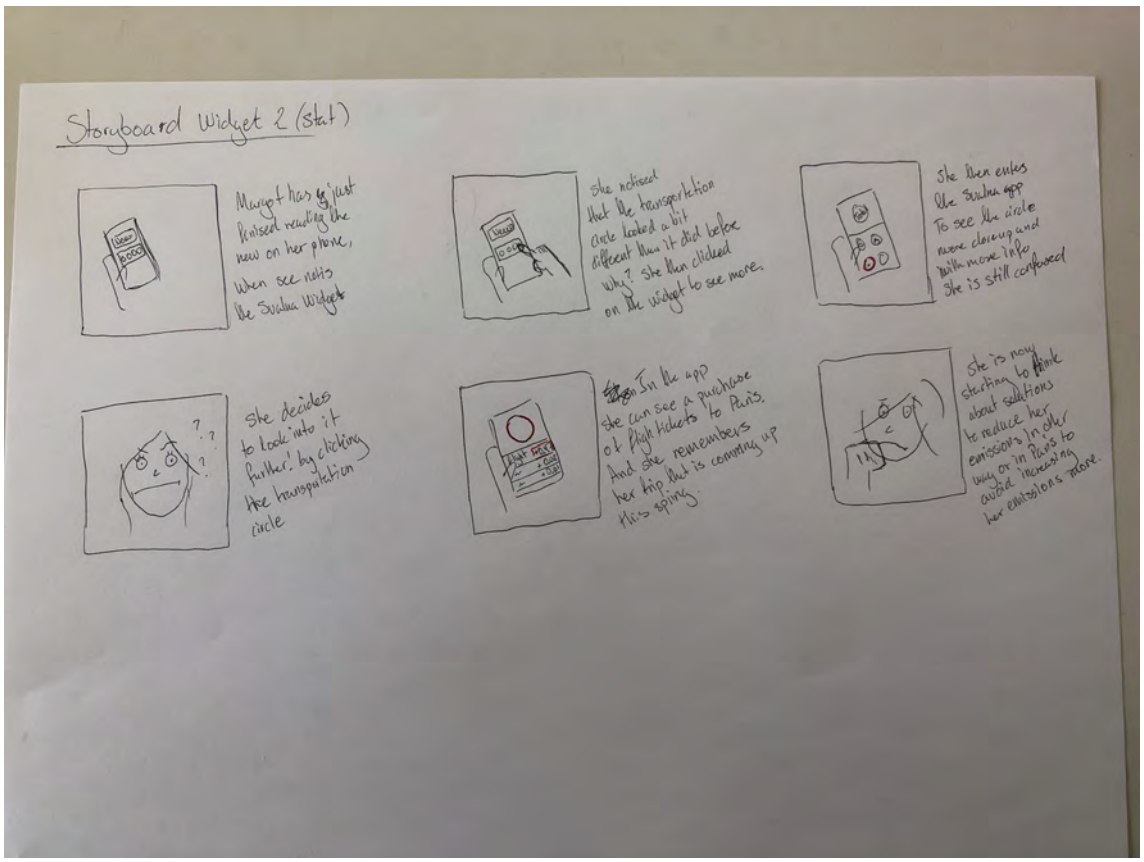

Figure B.5: A storyboard showing one version of the widget concept. It shows a widget with emission data visualized and how Margot interacts with it.

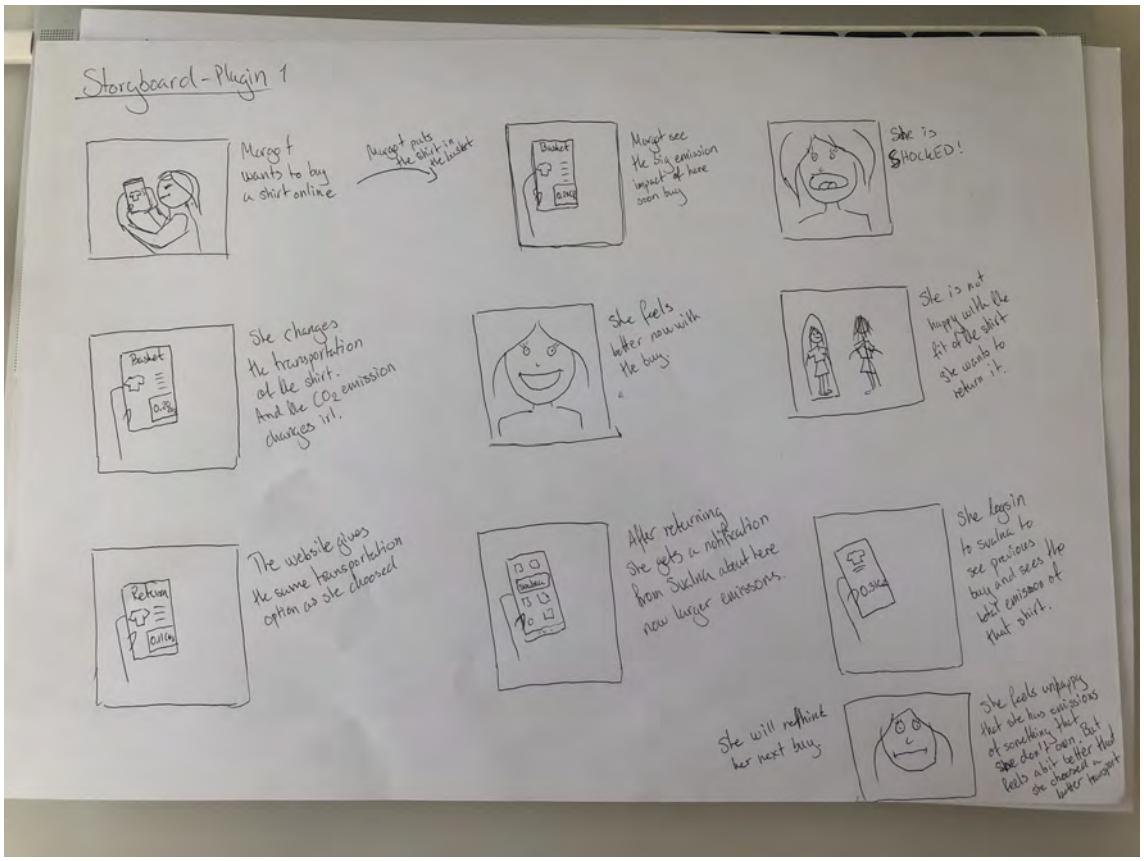

Figure B.6: A storyboard showing one version of the plugin concept. It shows Margot getting information on the emissions of her online purchases through a plugin.

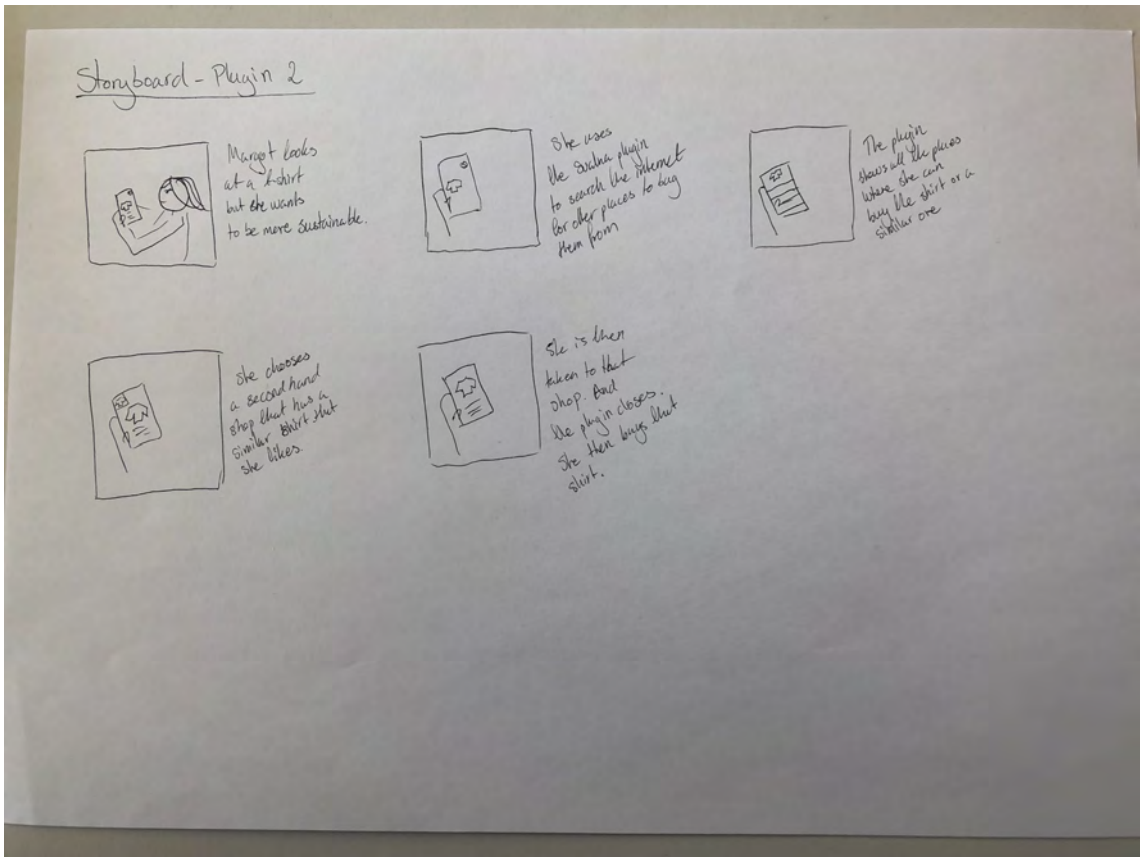

Figure B.7: A storyboard showing one version of the plugin concept. It shows Margot receiving suggestions on more sustainable purchases when online shopping though a plugin.

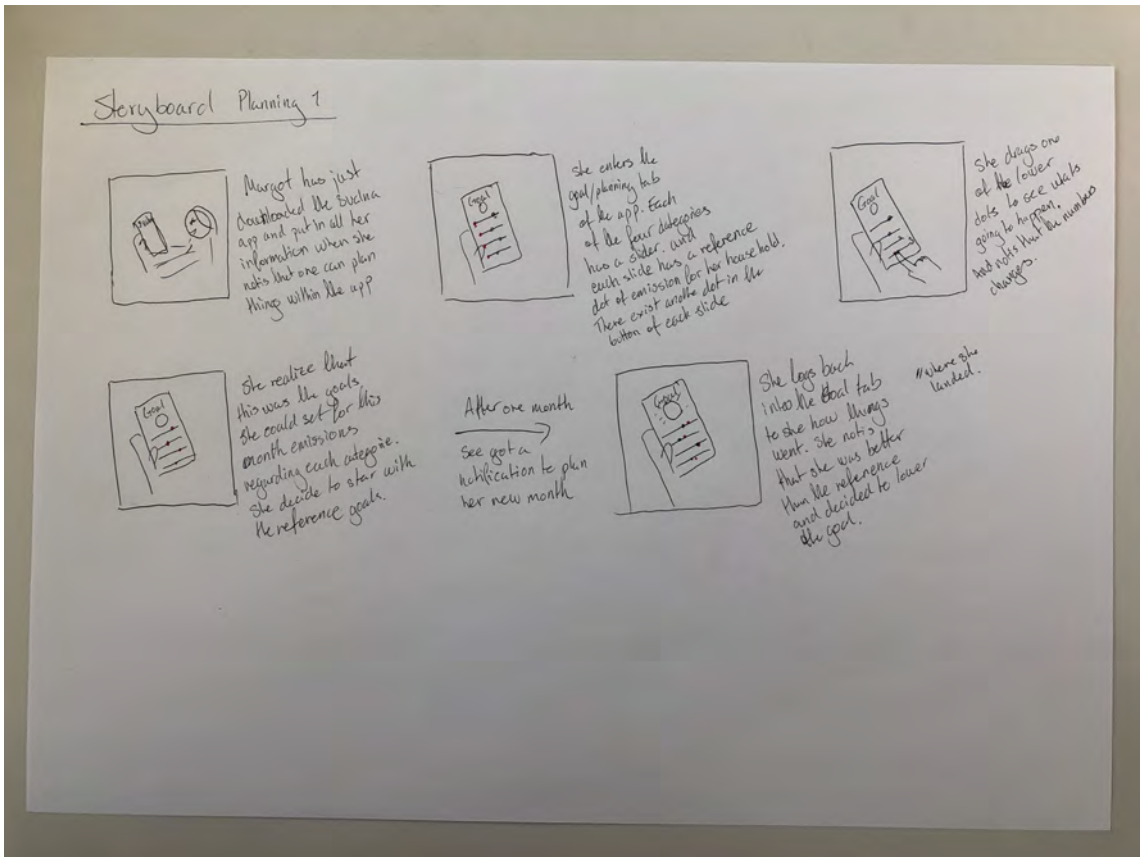

Figure B.8: A storyboard showing the planning concept. It shows how Margot uses the planning concept in the application to lower her emissions.