Sustainable living in the kitchen

MCKeasy

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ABSTRACT

As sustainability gains more importance, everyone can make individual decisions that contribute towards a more sustainable lifestyle. Consequently, this document focuses on showcasing a designed application aiming to guide users towards a more sustainable lifestyle in their kitchen, by fostering a sense of achievement, tracking users' savings, and keeping track of currently owned foods. An initial user study involving eight participants utilized a survey to explore sustainable solutions, attitudes towards sustainability, and user values. The study revealed experience goals such as a sense of achievement, efficiency, and ease, which were used to develop a prototype. It was evaluated with six participants, through questionnaires and tasks. Results notably revealed positive reception, providing a gaming-like experience, while also enhancing financial awareness and reducing food waste. While improvements were noted, like further automation, it was concluded that while the product wouldn't work as-is for long-term usage, instead teach the user long-term habits.

KEYWORDS

Sustainability, Recycling, UX, User Experience

USAGE OF AI TOOLS

Two AI tools, Grammarly and ChatGPT, were used in aid to check grammar, make sentences more comprehensible and clearer, as well as to check words and writing style in parts of this document.

1. INTRODUCTION

Consideration towards sustainability has gained more significance during the last few years. Sustainable living and decisions in daily lives are important because every action, whether harmful or beneficial for the world, becomes more impactful when more people adopt the same behavior. This can include for example recycling, taking into consideration grocery purchases, upcycling worn items, water and electricity usage and many other matters.

Many articles have already examined sustainability and recycling from different angles. For example, Nguyen et al. (2022b) explored the recycling habits of households and how some of the ways to dispose of food waste can be more sustainable than others (sorting food waste into organic bins, reusing food waste and composting). Perera et al. (2023) on the other hand investigated how to reduce household consumption by first understanding household consumption practices and then identifying concerns and challenges for household engagement with sustainable practices. They found how perspectives, understanding and motives for consumption reduction actively shape household practices.

Overall, there are many different ways to influence our habits towards household sustainability. These could be anything from keeping the house at a certain temperature, turning lights off in currently unused rooms or considering the usage of various electricity appliances in the house. Almost every room can be made into a more sustainable space with conscious choices.

When thinking about each room, we brainstormed to figure out which one had the most potential to become more sustainable. One room stood above the others in our discussion as well as research (Nguyen et al. 2022b) in a variety of ways to improve its' sustainability, the kitchen. Every house includes a kitchen, and kitchens in general share similar appliances and technology, such as a fridge, a freezer, an oven and a trash/recycling bin. Kitchens are the primary place to store food, to recycle and to use various home appliances. Thus, our document focuses on examining and designing an application that will help its users to thrive towards a more sustainable kitchen. The application will assist the user with creating sustainable habits such as improved grocery purchases, bringing more consideration to food consumption, and minimising food waste. Some features that the application focuses on are an icon that tells the sustainability level with expressions, financial reporting page and kitchen page, that lists currently owned groceries. Furthermore, in addition to deciding on the improved room, we decided on the target audience of the younger generation, (Gen Z to Millennials) residing in Finland and already

showing an interest in sustainability for our product. This decision was made because they already have some experience with sustainable habits and might aid from a product that supports this. While other sustainability apps exist, our application offers a fresh approach with its encouraging and motivating features, aiming to establish sustainable habits using methods such as gamification, that the user can then keep up, possibly even without the application.

This document begins with chapter two by reviewing related references and articles about sustainability. The beginning of this chapter explores sustainability first on a global scale, and after this on the individual and household level, going through topics such as food waste disposal behaviours and psychological factors that go into these behaviours. The rest of the chapter is assigned to explaining Hassenzahl's UX model in more detail, as well as experience-driven design.

Next, the document continues to chapter three and this document's basis and background for our application's design, the user study. This chapter goes through the used methods during the user study, as well as the results gathered during the user study, highlighting the most important insights, as well as a created persona based on the findings.

Chapter four goes into our tentative and final experience goals, explaining these in great detail. We clarify the process that led to the final experience goals, as well as how they manifest in our application. The rest of the chapter is dedicated to a thorough view of the prototype design, going through each design phase, our design choices and various elements and features, tying them in with our final experience goals.

Next, chapter five explains the methods used in our prototype evaluation, as well as the collected results, putting emphasis on how our experience goals were reached and how the participants felt about the prototype. Additionally, improvements suggested by the participants were also included.

Chapter six goes into our discussion about main findings during the project, limitations and future work for our product.

Lastly, chapter seven includes discussion about our team's group work.

2. RELATED WORK

The importance of sustainable living has increased significantly during the last few years. Global environmental challenges such as climate change have increased interest, leading to extensive research in this field. According to research, household consumption is responsible for 72% of carbon emissions (Perera et al., 2023). Gram-Hanssen (2008) states that energy consumption in similar households and houses may differ by 100%. The reason lies in daily routines such as keeping lower room temperature, using clotheslines instead of dryers and shutting off the standby consumption (Gram-Hanssen, 2008).

These actions significantly influence the household's CO_2 emissions. The study of Perera et al. (2023) showed the same results. Greenhouse gas emissions can be lowered significantly by adopting efficiency and limitation behaviours (Perera et al., 2023). According to Perera et al. (2023) e.g., insulating a building is categorized as efficiency behaviour while lowering the thermostat, closing the water tap while brushing the teeth and turning off the lights are limitation behaviours. However, people's actions could also be motivated by personal and social norms (Perera et al., 2023).

Moreover, Nguyen et al. (2022b) highlight that one-third of food produced worldwide is lost or discarded throughout the entire supply chain, with developed countries' households responsible for a significant portion of this waste. Therefore, Perera et al. (2023) argue that households play a crucial role in tackling climate change problems. One of the sustainable development goals of the United Nations is to combat climate change through tracking and immediate action (Perera et al., 2023).

Nguyen et al. (2022b) have studied household food waste disposal behaviour. According to them, social, environmental, and economic aspects of sustainable practices and decision-making are the three pillars of sustainability. Perera et al. (2023) state that when encouraging sustainable practices through technology interventions, it is crucial to prioritise user needs instead of blaming the user for the problem. The well-known fact is that for people it is difficult to change routines (Gram-Hanssen, 2008). According to Gram-Hanssen (2008), people change their routines frequently, but not because of environmental concerns. Instead, it is often influenced by shifts in the social dynamics of daily life and the integration of new technology. The research results by Nguyen et al. (2022) support previous findings that older people are more likely to use home composting than younger people. That's probably because the inconvenience cost for younger people is higher because of lack of time (Nguyen et al., 2022b). Similar results were found in a study conducted by Perera et al. (2023), which examined household consumption practices and challenges in adopting sustainable practices.

In their study, Nguyen et al. (2022b) noticed that various psychological factors, such as attitudes, perceptions, and emotions, can influence food waste minimisation behaviour. Individuals who experience guilt or perceive wasting food as bad are more likely to reduce food waste. Additionally, feeling obligated to avoid food waste or doing the right thing can also help to reduce food waste (Nguyen et al., 2022b). Perera et al. (2023) observed that people who are personally responsible for protecting the environment are motivated by their own values to take environmental actions, not by external pressure or rewards. Furthermore, they noted that participants' consumption-related actions were influenced by their practices, attitudes, and cooperative household activities. Gram-Hanssen (2008) found that childhood norms, such as cleanliness and spending habits, can influence current behaviour. Nguyen et al. (2022) presented

evidence that psychological, behavioural and situational factors, along with socio-demographic and household characteristics, play a role in shaping sustainable food waste behaviours within households. Previous research has also shown that socio-demographic characteristics, including age, gender, education level, household size, household income, housing type and having children in the household, can influence food waste behaviour (Nguyen et al., 2022b).

The study conducted by Perera et al. (2023) revealed that 21 out of 22 respondents were willing to make improvements in energy consumption practices, with food waste being considered the least significant concern. This finding contrasts with the observation of Nguyen et al. (2022b), who emphasized that households in developed countries contribute significantly to global food waste. Further discussion revealed that the motivator for the willingness to make improvements in energy consumption practices was increased energy costs (Perera et al., 2023). Also, the research by Nguyen et al. (2022) showed that the effort needed to sort food waste and the needed money to acquire necessary equipment can be a barrier to acting sustainably. Previous research has shown that financial factors are often more important than environmental factors (Nguyen et al., 2022b).

2.2 UX and Hassenzahl's UX model

The term UX is widely used but being interpreted in various ways. According to Lallemand et al. (2015), background variables affect the understanding of the user experience. Norman Nielsen defines user experience as the interaction between customers and a company's products and services. (*The Definition of User Experience (UX)*, n.d.). Lallemand et al. (2015) emphasize that Hassenzahl and Tractinsky characterize UX as "a consequence of a user's internal state, the characteristics of the designed system and the context within which the interaction occurs". Thus, UX extends the concept of usability by encompassing emotional, subjective, and temporal elements that play a role in the interaction (Lallemand et al., 2015).

Hassenzahl has designed a UX model to identify and explain the essential components of user experience and their functional relationships. It considers the subjective nature of experiences, the way products are perceived, the emotional responses of users to products, and the impact of different situations on these experiences. (Hassenzahl, 2018.) We chose Hassenzahl's UX model for our project because it focuses on user experience in a versatile way. It encompasses both pragmatic and hedonic aspects, which are particularly relevant to our project, with a specific emphasis on hedonic aspects. Our application aims to promote sustainable operations by reducing food waste, which requires a deep understanding of users' emotions, experiences, and motivations. This information helps us design the intended user experience so that it supports users in making sustainable choices, especially decisions related to food disposal or saving. Hassenzahl's model provides a good framework for this purpose.

In Hassenzahl's model of UX, the designer conveys the intended product character through selected product features such as content, presentational and interactional style, and functionality (Hassenzahl, 2018). However, everyone creates their own concept of the product character which is called the apparent product character in this context. Thus, this means that users' perceptions of the intended character may vary greatly. The apparent product character is categorized into pragmatic and hedonic attributes (Hassenzahl, 2018). Hassenzahl categorises attributes such as controllable, useful, supportive, and clear being pragmatic. A pragmatic product is used to achieve behavioural goals, like using a tool for a specific task. All other attributes are considered hedonic, and they are related to individuals' psychological well-being (Hassenzahl, 2018).

Hassenzahl divides the product's hedonic functions into three subclasses: stimulation, identification, and evocation. Stimulation means that the product should offer users new impressions, opportunities, and insights. Identification is about how individuals express themselves to others and seek social recognition. Lastly, evocation refers to a product's ability to evoke memories that are important to an individual. (Hassenzahl, 2018.)

In the design process, selecting the appropriate product character is important, considering attributes that users expect (Hassenzahl, 2018). For example, users expect reliability, security, ease of use, and accurate product information in online shopping. The website's appearance, including layout, colours, font, and elements, needs to support the chosen product character. When users encounter the product or service for the first time, the apparent product character is shaped by the individual's personal features and the surrounding context (Hassenzahl, 2018). This can lead to a perception that may significantly differ from what the designer has intended. According to Hassenzahl subsequent reactions, such as approval or dislike, are the outcomes influenced by these factors. In addition, the perceived apparent product character can change within an individual as they gain more experience with the product (Hassenzahl, 2018). For example, a product that was initially frustrating to use may become more satisfying as users become more familiar with it. Hassenzahl also points out that consequences may vary more than perceptions because of the usage situation. An example is a product that initially brings pleasure but may become irritating as it slows down goal achievement and is no longer necessary.

2.3 Experience-driven design

User experience is subjective and depends on the context of use. Therefore, experience cannot be designed, but designers can design for the experience. The starting point of Experience-driven design (EDD) is to discover people's experiences, which determine the design direction of the product or service and its characteristics. According to Chowdhury et al. (2020), the EDD approach assists in specifying experiences that need to be taken into account throughout the design process.

Chowdhury et al. (2020) state the design process starts by specifying user experiences relevant to a specific technology. These experiences are derived from users' needs and values (Chowdhury et al., 2020). The key in EDD is to find an answer to three questions: "Why?", "What?", and "How?". Hassenzahl (2010) categorizes the first question "Why?" as a be-goal which deals with why the user uses or interacts with the product and what are the needs or emotions that motivate them to do so. The "Why" goals may include psychological needs like pleasure. For instance, someone may require a sense of calm and relaxation before an important meeting. They utilize Spotify to discover relaxing music or meditation recordings, fulfilling their be-goal. This demonstrates how experience goals can make the interaction with a product meaningful. The do-goals, "What?", are concrete goals that users want to achieve using the product or interacting with it (Hassenzahl, 2010). An example of a do-goal is "make a phone call" or playing music". Motor-goals, "How?", are related to do-goals and determine how the user can interact with the product and achieve do-goals (Hassenzahl, 2010). For example, a user can achieve a do-goal "make a phone call" by typing a number, selecting a person from the phonebook, or giving a voice command to call a specific person.

3. USER STUDY

In this project, we have conducted an interview and survey-based user research. The research aims to understand potential user attitudes toward sustainable living and their needs and pain points when adapting to sustainable practices and habits to inform design decisions in later phases.

3.1 Methods

As the project focuses on identifying design decisions in the early phases of a new product based on potential users' behavior and attitudes, we have decided to select a qualitative research approach. Qualitative methods focus on gathering non-numerical data and insights about users' behaviors, attitudes, and experiences and are particularly valuable for gaining a deep understanding of user needs, preferences, motivations, and pain points.

In user experience research, user interviews represent a widely employed approach. They have a broad applicability, encompassing a wide range of user-centric subjects. For instance, they can be utilized to acquire insights into users' emotions, driving factors, daily habits, or their interactions with diverse products. The interviews often follow the same methodology as qualitative interviews in other fields, but their primary aim is to provide insights for design projects. Given that user interviews often need to align with design or development timelines, practical considerations, such as time constraints and resource availability, frequently influence the approach taken in conducting these interviews.

In our research, we have gathered answers from eight participants in total. Our target user group is people belonging to the younger generation (Gen Z to Millennials) living in Finland and already have an interest in sustainability. According to First Insight Inc (2020) report, Gen Z and Millennials are the most likely to make purchase decisions based on values and principles and are willing to spend 10% or more on sustainable products. At the same time, our target user group generation is the one that is most familiar with modern technology, such are smartphones and software applications. Thus, we view this group as the most potential customer segment with high demand for the services we are trying to deliver.

Because some participants have a tight schedule, we have decided to create a survey version of the interviews so that busy participants can still share their insights with us at their own chosen time. Before the interview, all participants were introduced to research purposes and processes and how data is collected and stored. By participating in the interview, participants gave us consent to the terms and conditions we had stated earlier. During the interviews, we collected participants' research-related personal information, such as living conditions, income and personal habits, and insights from them by taking notes. These notes were then analyzed using the thematic analysis method to find out key issues that the potential users are concerned about. These findings are discussed in the Results section.

3.2 Results

The findings from our user research on sustainable living solutions in the kitchen reveal several key insights.

- ★ **Waste Avoidance and Recycling:** A predominant concern among users is the minimization of waste, spanning across multiple domains. Participants emphasize their commitment to reducing food waste, conserving energy, and using water efficiently. Recycling practices are also a focal point, reflecting a strong desire to contribute to waste reduction efforts in their daily lives. These findings suggest that sustainable kitchen solutions should prioritize features and designs that facilitate waste reduction, energy efficiency, and responsible water usage.

- ★ **Financial Motivation:** Surprisingly, more than half of the participants indicate that financial considerations are the primary drivers behind their adoption of sustainable living practices. This underscores the importance of cost-effectiveness in sustainable solutions. To appeal to this segment of users, sustainable kitchen solutions should not only offer eco-friendly benefits but also demonstrate long-term cost savings and financial advantages.

- ★ **Environmental Responsibility and Morality:** Users express a profound sense of responsibility toward the

environment. They view their sustainable choices, no matter how small, as meaningful contributions to a better world. This sense of environmental stewardship not only motivates their sustainable living but also brings about moral satisfaction. Designing kitchen solutions that align with these values and provide opportunities for users to feel their actions are positively impacting the environment can be highly effective.

★ *Social and Media Influence:* Half of the participants acknowledge the influence of friends and media sources in motivating their sustainable living practices. This highlights the importance of social networks and informational channels in promoting sustainability. It suggests that marketing and awareness campaigns, as well as product recommendations from trusted sources, can play a pivotal role in encouraging sustainable behaviors in the kitchen.

From the research results, we have created a persona of our potential users as seen in Figure 1. Persona's traits can be seen in Figure 2:
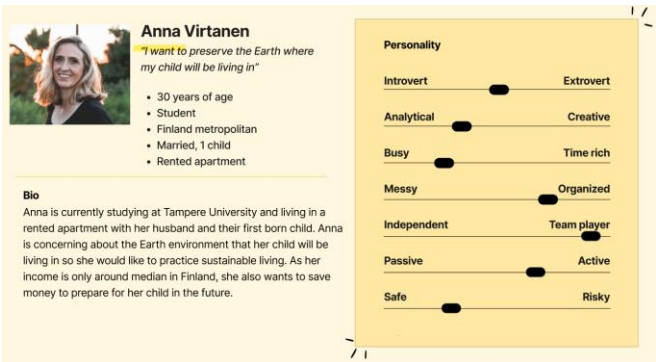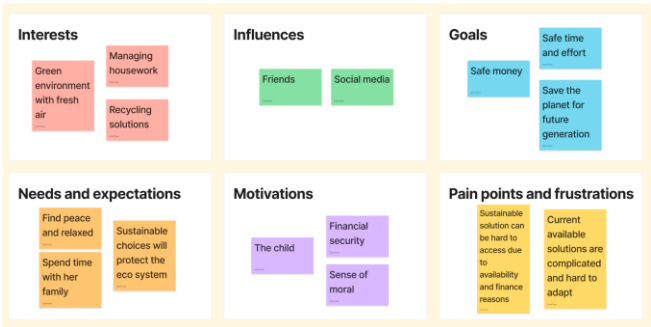

Figure 1: Persona

Figure 2: Persona's interests, influences, goals, needs and expectations, motivations and pain points and frustrations

4. THE INNOVATIVE APPLICATION FOR MORE SUSTAINABLE CHOICES IN THE KITCHEN

In this chapter, we'll explain both tentative and final experience goals and where they are based on. Additionally, we'll describe the prototype with the reasoning of the features, our motivations and how the features and functions are connected to the final experience goals.

4.1 Experience Goals

This subsection contains sections Tentative Experience Goals and Final Experience Goals. In these sections, we explain the intended experience goals of our design and the reasons behind the selected UX goals.

4.1.1 Tentative Experience Goals

The tentative experience goals are derived from brainstorming and the preliminary user study, as well as prior knowledge of people's basic needs and related studies. During the brainstorming session, we explored the factors motivating sustainable behaviour and the emotions associated with such actions. One of the initial observations was the need for individuals to feel that they are doing something meaningful to contribute to the preservation of our planet. The initial user study confirmed this assumption. Other factors that emerged included the satisfaction of reducing food waste, a sense of efficiency and ease, and a feeling of health and well-being.

Additionally, we assumed that people may be reluctant to invest significant effort in adopting sustainable practices in their daily lives. Therefore, sustainable practices in the kitchen should be simple and efficient. While making this assumption, we considered scenarios like a working mother with several children who might have limited time and resources, unlike elderly individuals, for example. The studies of Nguyen et al. (2022) and Perera et al. (2023) supported the previous assumption. The study conducted by Nguyen et al. revealed that older people are more likely to use home composting than younger people. This is likely because younger individuals face a higher inconvenience cost, primarily because they have less available time (Nguyen et al., 2022b). Perera et al. conducted a study that yielded comparable findings when investigating household consumption practices and the difficulties in adopting sustainable behaviours.

Additionally, based on our prior knowledge, one of the tentative UX goals was to foster a sense of belonging. It's a known fact that people have a natural desire to be a part of a community.

The Tentative Experience Goals include:

- ★ a feeling that is doing something meaningful

- ★ satisfaction with reducing food waste

- ★ a sense of efficiency and ease

- ★ a feeling of health and well-being

- ★ a sense of belonging

4.1.2 Final Experience Goals

Our final experience goals were derived from a blend of existing literature and insights gathered from our user study. The literature review provided initial indications supporting our hypotheses. For instance, our assumption that financial factors drive individuals to reduce food waste, aligns with prior research, reinforcing the establishment of the "Financial Safety" goal. Similarly, previous studies highlighted time constraints as a barrier to sustainable practices, resonating with our observation of time scarcity affecting sustainable actions, leading to the formulation of "A Sense of Efficiency and Ease."

Moreover, our user study reinforced these assertions. Participants exhibited a strong sense of environmental responsibility and perceived even minor sustainable choices as meaningful contributions to a better world. This corroborated with the literature emphasizing users' ethical motivations and contributed to the establishment of the "A Sense of Achievement" and "A Sense of Satisfaction" goals.

Therefore, the final UX goals are results from our initial assumptions validated by existing literature and reinforced by practical insights obtained through our user study. The four final UX goals are:

- ★ *A sense of achievement:* Users should receive constructive feedback on their actions to help them understand what they have accomplished and how they can improve. To address this goal, our application should offer guidance on enhancing sustainability and provide users with both short-term and long-term feedback. Additionally, the incorporation of gamification elements will motivate users to achieve their objectives.

- ★ *A sense of satisfaction:* Our user study revealed that users express a deep sense of responsibility toward the environment. Individuals prioritising sustainability see their choices, regardless of size, as significant contributions to a better world. This sense of environmental responsibility not only inspires them to lead a sustainable lifestyle but also provides them with a sense of moral satisfaction. To incorporate this goal into the prototype, we should focus on creating features and functionalities that allow users to clearly see the positive impact of their actions on the environment. For

example, we can provide real-time feedback on how their sustainable choices reduce their carbon footprint. In this way, we can enhance the user's sense of satisfaction and connection to a greater cause.

- ★ *Financial safety:* More than half of the participants in our user study identified financial factors as their primary motivation for adopting sustainable living practices. They expect to save money by reducing food waste, which provides them with a sense of financial safety and security. To address this goal, our application should incorporate features that clearly demonstrate the potential long-term financial savings associated with reducing food waste. This can be achieved by providing users with data on their food consumption and waste reduction and estimating the cost savings over time. Additionally, the application can offer tips and suggestions for budget-friendly, sustainable food choices and meal planning. By focusing on these aspects, the prototype can enhance the user's perception of financial safety and encourage them to continue adopting sustainable practices.

- ★ *A sense of efficiency and ease:* As the results of related studies indicate, younger people often have limited time and resources for sustainable actions compared to elderly individuals. Therefore, it is essential that living sustainably and making eco-conscious decisions are straightforward and efficient. To meet this need, the design should provide various methods for adding products, emphasizing the importance of streamlining the product management process. In essence, the user interface should be clear and simple to ensure that the application's functions are easy to notice, learn, and use.

4.2 Prototype Design

In this chapter we will be going into detail on how we designed our prototype, why we made certain choices during the design process, how these decisions match with our findings from the user study and further, how different functionalities tie in with our final experience goals. We had three clear phases for the design process: Low fidelity phase, refining phase, and prototype phase. In short, in the low fidelity phase, we established the main functions of the application, in the refining phase we made the look of the application more cohesive, and in the prototype phase, we added the ability to move between the views when clicking buttons, as well as did refining for the visuals and functions.

Link to prototype:

https://www.figma.com/proto/uOjZpM61dwOO9Vkr1nNkpX/Product-design?type=design&node-id=53-1128&t=5F6w6bq0yoNFUvEZ-1&scaling=scale-down&page-id=7%3A3&starting-point-node-id=53%3A1128&show-proto-sidebar=1&mode=design

Low fidelity phase

After gathering our results, we initially began working on creating wireframes for our application. Our goal with this phase was to outline the most important views and functions in our application by following our experience goals and own plans. We identified the essential pages for the application to include the main functions, these being a home page, a kitchen page, and a progress reporting page.

The application has a navigation bar at the bottom of the screen, which the user can use for seamless navigation through each page. Each navigation icon clearly indicates the content accessible when clicked. The first icon in the navigation bar leads to the home page.

The home page as seen in Figure 3 is the first page the user sees when they open the application. The main feature on the home page is an icon that reflects the state of the user's current sustainability level in emotions; when user has practiced a lot of sustainability, the icon is smiling, and when the user has paid less attention to sustainability, the icon is frowning. This icon is the main contributor to the user's sense of achievement and satisfaction. The user can directly observe their own sustainability efforts from the emotional response of the application. By putting in more effort, the user gets direct positive feedback, showing that they have done a good job.

Figure 3: Wireframe of the home page

Additionally, the home page features a button "Sustainability coach" that leads the user to a sustainability coach, as seen in Figure 4 on the left. The coach page offers a detailed overview of the user's sustainability practices and gives a more comprehensive interpretation of the icon's emotional state. This page also provides sustainability tips, such as telling the user to freeze their leftover food, or reminders to recycle packages. Essentially, the sustainability coach supports the application's ease of use by allowing the user to look at the emotion icon first, and explore a more detailed description of their habits, if desired. Additionally, it aids in adapting to new habits, by offering new tips and giving reminders.
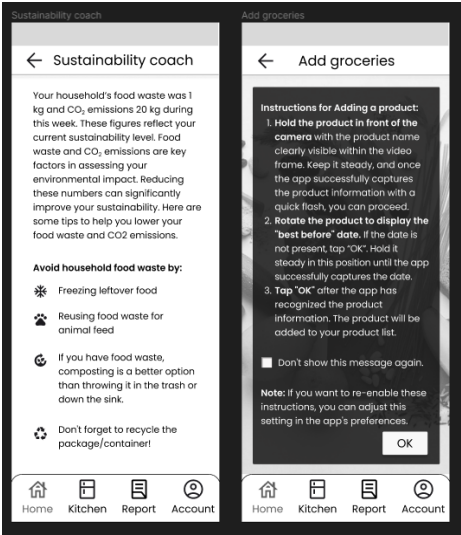

Figure 4: Wireframes of the sustainability coach and adding groceries

The "Add groceries" button in Figure 3 lets users add their groceries to the kitchen view. In short, the user can take a picture of a new grocery item, the application will recognize and add it to the list of groceries in the kitchen view. Our application will utilize the Optical Character Recognition (OCR) technology to enable text in images to be recognized and converted into digital form for processing and storage, along with machine vision for object recognition. A short tutorial for adding a product can be seen in Figure 4 on the right before the user can take the picture.

The next icon in the navigation bar leads to the kitchen page as seen in Figure 5. Here the user can view, sort, and edit their current groceries registered to the application. The view can be switched between the fridge and cupboard, listing the various groceries in these places, as seen in Figure 5 on the left. Each grocery has its own listing element, which shows a picture of the food, its name, and the date of expiration. If the expiration date is very near, the application will warn about this by showing a red warning sign next to the food. If the user wants to edit a certain grocery, they simply click on the food on the list, which takes the user to a view seen in Figure 5 on the right. Here, the user can edit aspects of the food, such as its date of purchase and expiration, as well as the amount of the product they currently have. When the user edits the amount, they can specify whether they ate or threw the edited amount into the trash.
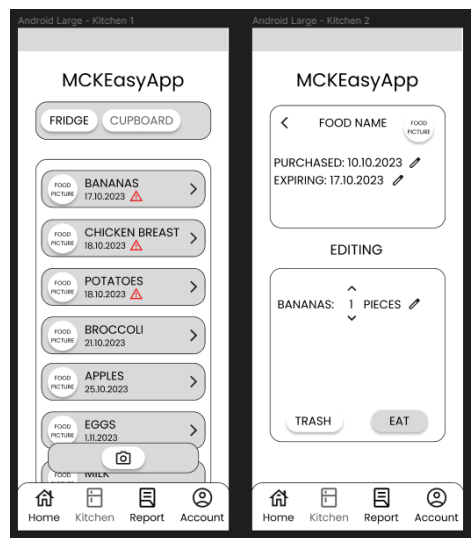
Figure 5: Wireframes of the kitchen listing and editing pages

Figure 6: Wireframe of progress reporting page

The kitchen page was designed with the experience goal of efficiency and ease in mind: it should be easy for the user to be able to learn the application, add new groceries, navigate around and overall perform every step of the process efficiently, without too much hassle. For example, instead of having to write or manually log every grocery to the application, taking a picture can be much quicker. The possibility to scan groceries can be found both on the main page and also in the kitchen view, in the form of a camera icon at the bottom of Figure 5's image on the left. The wireframe was designed to only include the most important features, but the next phases will take the aesthetic side of the experience goal such as clarity even more into consideration.

The last icon in the navigation bar leads the user to the progress reporting page, as seen in Figure 6. Here the user can find the statistics calculated based on their sustainability habits and actions. Most importantly, the user can track their savings during a specific timeframe. This follows the experience goal of financial safety, showing the user how much they can save money with sustainable habits. Seeing this in a clear and understandable format can motivate the user to maintain sustainable habits, recognizing the value of their efforts. Additionally, this page features a meter that tracks user's savings towards a goal. This adds a sense of achievement in saving money, as well as a gamifying element into the application.
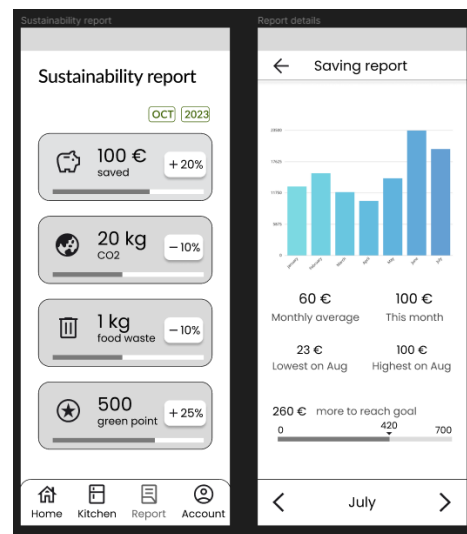
Refining phase

After figuring out the basic layouts for the application's features in the low fidelity phase, we moved to the refining phase where we focused on making the whole look of the application more cohesive, with the use of colors, fonts and elements, while also putting more emphasis on our experience goals.

Since the application is designed to encourage sustainable habits, the visuals should complement this. This included agreeing on a color palette that was followed through the whole application. The color palette includes various shades of green and yellow as primary colors and shades of red and blue as secondary colors. This color palette was chosen to go with a positive, nature-like feel. The colors can be seen in the following Figures. The colors were chosen to have enough contrast between each other's, so that fonts and other elements are clear and legible.

Similarly, various shapes are designed to have similar sizes and colors. This gives the user a visual sign of which elements the user can interact with, and which belong to a group. An example is light-yellow elements in Figures 9 and 11.

An element that was enhanced to bring in more emphasis on the experience goal of being a part of something bigger was changing the icon in Figure 3. The new icon, an image of the Earth can be seen in Figure 7. The shape of the Earth can give the feeling that the user is directly contributing to the well-being of the Earth with their sustainability efforts. The colors of the buttons and the text "Sustainability level" were also changed to visually sign the changing emotions.
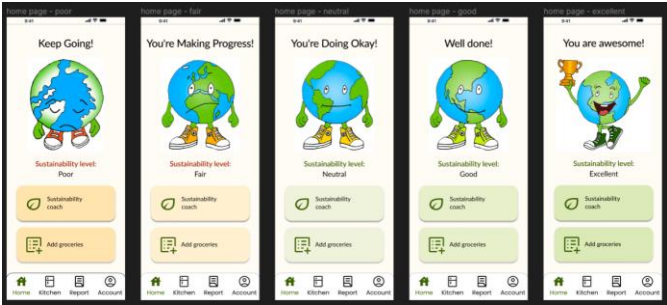
Figure 7: Refined home page

Improved and cohesive colors were also added to various icons around the application. This can be seen for example in Figure 8, in the Sustainability coach. Additionally, the icons for the navigation bar were also emphasized, filling the current page's icon in dark green color, making it easier to visualize where the user currently is.
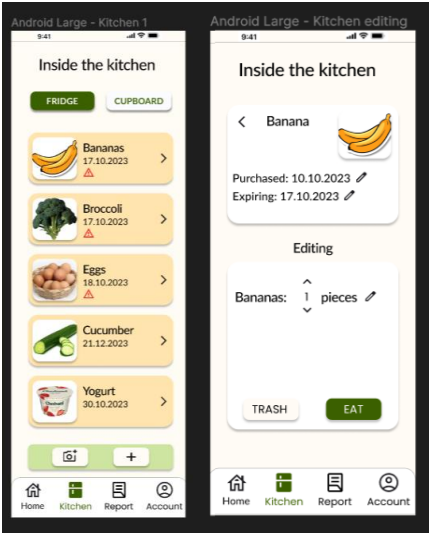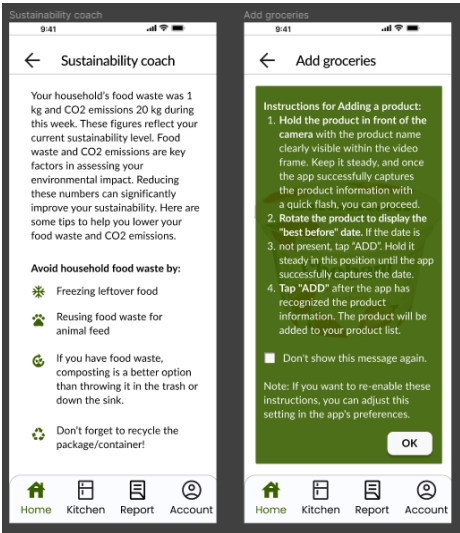

Figure 8: Refined sustainability coach and adding groceries

Most of the elements and buttons were made clearer and grouped together with similar elements with the use of color and size in the kitchen listing, as seen in Figure 9. Namely, now users can see easily which location, the fridge or the cupboard, they are currently inspecting. Additionally, the listing elements for the groceries were made bigger, so they are easier to see and click.
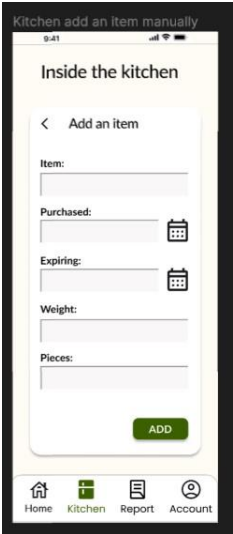

Figure 9: Refined kitchen listing and editing pages

A new page for adding groceries manually was also created, as seen in Figure 10. This can be accessed in Figure 9, through the button with a plus icon, next to the camera icon. This functionality was designed to add items to the list, such as groceries without labels or miscellaneous items. It can also be used when the user's phone camera is malfunctioning or unavailable.

Figure 10: Manual adding page

The progress reporting page stayed quite similar compared to the wireframe. The refined progress report can be seen in Figure 11. The addition of colors to the various percentages in the elements makes it easier for the user to see which aspects of sustainability they have improved and which they could pay more attention to.

Figure 11: Refined progress reporting page

Figure 13: Final kitchen listing page

Prototype phase

In this phase, we focused on further refining the look of the application, as well as adding the ability to move between various views. The final prototype with interactions can be found at the link, at the beginning of this chapter.

Even though the biggest changes in this phase were adding the interactions, some visual improvements were also made. One of the notable ones was on the home page, changing all of the buttons in various emotional states in Figure 7 to be the same color, as seen in Figure 12. It was decided that the description of the sustainability level (Poor -> Excellent) would change the color instead. This decision was made to keep the overall visuals and colors always the same, as well as to keep the contrasts in the buttons the same every time.
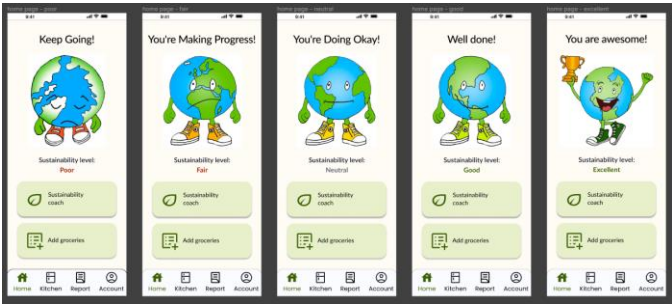
The final bigger refining done during this last phase was to make the grocery editing page clearer. Previously, in Figure 9, editing the dates and amounts was done using small pencil icons. These icons were quite small, meaning that they were more difficult to see and click. Additionally, these icons gave little information about what and how they were going to edit. All of these aspects were improved in Figure 14, by adding proper buttons for editing next to each label. Now, it's much easier to visually find the editing buttons, as well as to understand what they are going to edit. These improvements help with the experience goal of a sense of efficiency and ease, improving the interface's noticeability.

Figure 12: Final home page

The kitchen listing page's buttons for scanning and adding items manually were changed from Figure 9 to a more cohesive look to match other similar buttons in the application. The new buttons can be seen in Figure 13. This new look makes the buttons more visible and easier to find.
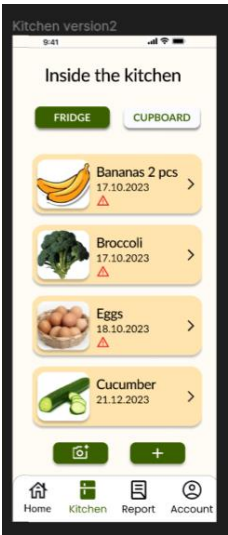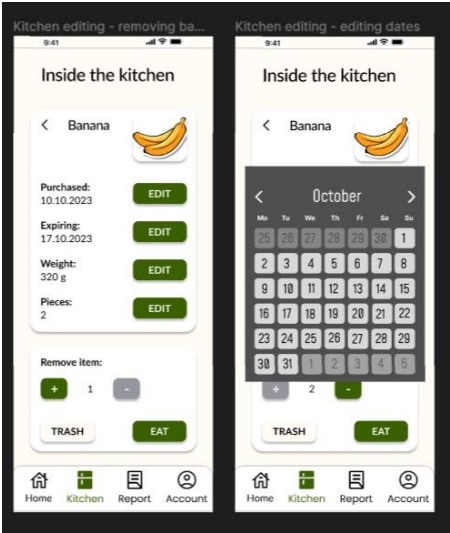

Figure 14: Addition of editing buttons to the editing page

The last refining done to the editing page was to change the color of the Trash button to red, as well as separate the Trash and Eat buttons from the background, as seen in Figure 15. This visually emphasises that these buttons finalize the edits done by the user, as well as that the Trash button means that the user has discarded the food and this counts towards being unsustainable.
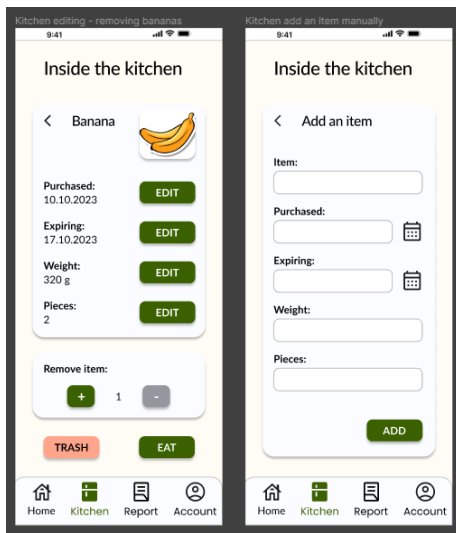

Figure 15: Final editing page

5. PROTOTYPE EVALUATION

In the ever-evolving landscape of product design and development, the assessment and refinement of prototypes are critical milestones in ensuring the creation of user-centered and efficient solutions. This prototype evaluation study represents a pivotal step in our ongoing efforts to craft a seamless and user-friendly product. The focus of this research is to rigorously examine the usability, functionality, and overall user experience of our prototype, which has been meticulously developed in response to user needs and feedback. In this section, we present the methodology we used to evaluate our prototype and the result of the evaluation.

5.1 Methods

In this user experience evaluation, six participants are engaged in one-on-one sessions where they will perform specific tasks within the mobile application prototype. The research team will observe participants' interactions, behaviors, and performance during the task execution. This approach provides valuable qualitative insights into the usability, functionality, and user-friendliness of the application.

Following the task completion and observation phase, participants are required to complete two distinct types of questionnaires to obtain a comprehensive understanding of the user experience:

a. Qualitative Questionnaire: This questionnaire is designed to elicit detailed feedback from participants. They will be asked to complete sentences that are partly provided, allowing them to express their experiences, feelings, and thoughts about the mobile application prototype. The qualitative questionnaire aims to capture in-depth insights related to the user experience goals we presented in section 4. The qualitative questionnaire is crafted following the instruction by Kujala et al. (2013).

b. Quantitative Questionnaire (AttrakDiff): The AttrakDiff questionnaire is created based on Hassenzahl's UX model to assess the user experience quantitatively. Participants are presented with ranking questions that help measure the perceived usability, aesthetics, and overall appeal of the mobile application prototype. This quantitative approach provides a structured assessment of the application's usability and user satisfaction.

The collected data from the user interviews, observational notes, and questionnaire responses will be subjected to rigorous analysis. The qualitative questionnaire responses will undergo thematic analysis to identify recurring themes, while the AttrakDiff questionnaire results will be analyzed quantitatively to gauge overall user satisfaction and perceived usability.

5.2 Results

The evaluation revealed the overall impression of the design is good as each participant conveyed a positive experience with the application, noting its user-friendly interface and aesthetically pleasing design. The AttackDiff questionnaire result can also confirm the result with the Pragmatic quality point standing at 1.79 (Figure 16) and the Attractiveness value at 1.55 (Figure 17). However, the Hedonic quality point is below average and only stands at 0.7 (Figure 16) with the lowest value being Stimulation at 0.5 (Figure 17).
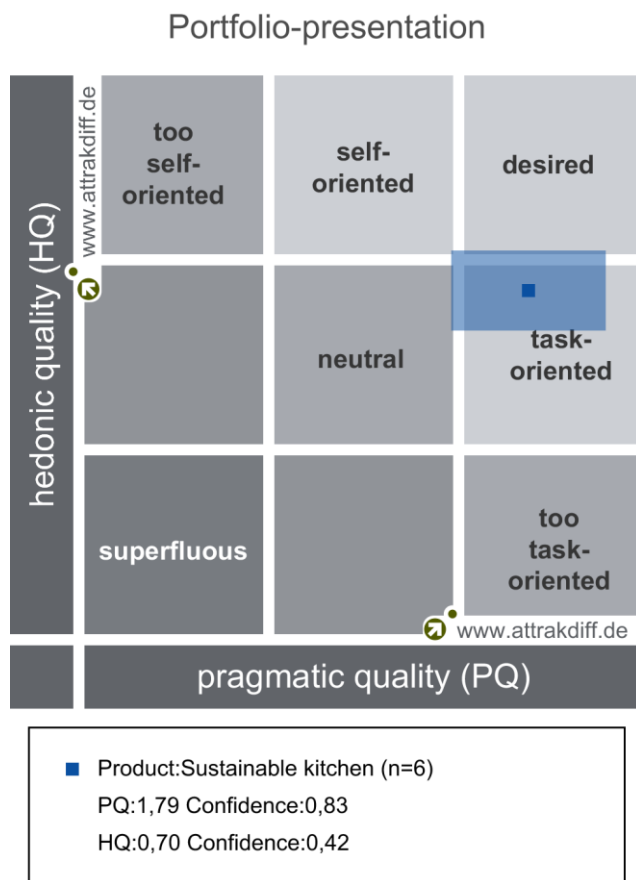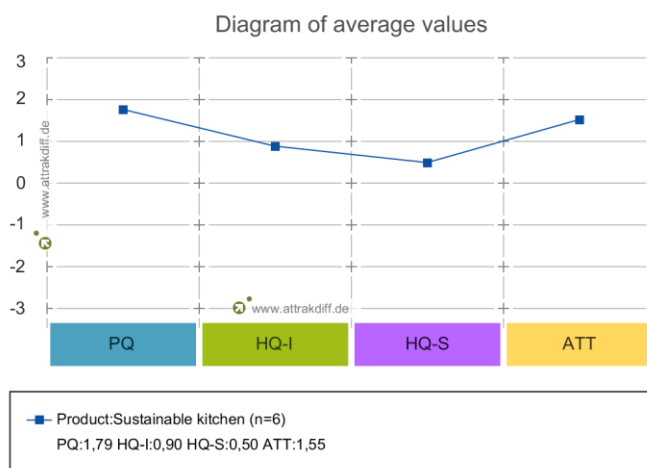
Figure 16: Portfolio of result

Figure 17: Diagram of average value

When we look into more details when analyzing the qualitative data, the design prototype appears to satisfy all user experience goals we have set.

1. Financial Safety Goals: The application unequivocally met financial safety goals, with all participants attesting to an increased sense of financial consciousness and security.
   Participant 1: "The application probably would help improve savings, especially as a student with food waste and make life easier"

2. Efficiency and Ease: A unanimous sentiment of efficiency and ease was pervasive among participants, who adeptly completed assigned tasks swiftly. The consensus was that the application's navigation and comprehension were seamless.
   Participant 1: "It is easy to use because it is so intuitive and offers enough user help in the layout and things to learn how to use it fast".
   Participant 6: "I find it easy to use because the visuals are simple, there is no clutter around elements and colors."

3. Sense of Satisfaction and Achievement: Participants expressed a profound sense of satisfaction derived from meaningful actions contributing to a larger purpose. Four of the six participants, particularly attuned to concerns about food waste and the environment, found the application to be a fitting solution. Beyond sustainability, they recognized additional benefits, such as improved kitchen organization and guidance toward sustainable practices.
   Participant 3: "It would be nice to know that you are able to save up the food consumption cost, while able to see your contribution to global sustainability trend of the world"

Beyond UX goals, participants universally emphasized feelings of curiosity and joyfulness, underscoring the application's success in delivering a captivating experience akin to gaming, notably achieved through the animation-like design of the planet earth featured on the home page. The primary objective of promoting sustainable living was also unequivocally realized. The application's ability to evoke positive emotions, coupled with its utility in enhancing financial awareness, facilitating task completion, and reducing food waste, positioned it as a potent tool in fostering sustainable lifestyles.

Participant 5: "the earth illustration, it creates the gamification feeling"

Participant 6: "seeing the face of the Earth change, because it brought me joy to see it happy...... I believe the application can help me organize my kitchen even better."

Participant 4: "it could be the sustainability coach for people concern about environment, health and money"

Finally, participants also provided constructive feedback, suggesting areas for improvement. Concerns were raised about the

manual management of kitchen items being time-consuming, prompting recommendations for streamlining processes, particularly in adding food items. Collaborative efforts with K-Ruoka and increased automation in grocery management were proposed. Furthermore, participants advocated for an expanded application scope, encompassing additional sustainable activities such as secondhand stores or food sharing.

6. DISCUSSION

The goal of the user study was to find out the users' needs, experience goals, behaviour, attitudes, and motivators related to sustainable living. The original purpose was to collect data through interviews, but due to the time constraints of the participants, we ended up sending the participants a questionnaire instead of interviewing them. The results were analyzed using the thematic analysis method.

Based on the results of the user survey, we designed motivational software, which considers users' needs and experience goals based on the user study. User experience evaluation was used to study the usability, functionality, and user experience of the prototype. During these one-on-one sessions held either in Teams or face-to-face, we observed participants' behaviour, interaction with the prototype, and performance with the tasks. Users conducted four predetermined tasks on a prototype mobile application. After this, qualitative and quantitative data were collected from the participants to gain a deeper understanding of the user experience. The qualitative questionnaire, which was a sentence completion form, comprised 13 sentences that participants filled out. In the Qualitative questionnaire, AttrakDiff, participants were presented with ranking questions that helped measure the perceived usability, aesthetics, and overall appeal of the mobile application prototype. This approach provides a structured assessment of the application's usability and user satisfaction.

The evaluation results show that the design prototype has received positive feedback from all participants. They found the interface user-friendly and aesthetically pleasing. The design appears to have met all the user experience goals that were set.

6.1 Main findings

Throughout the entire supply chain, food waste is responsible for one-third of the food produced worldwide, with households in developed countries contributing significantly to this waste (Nguyen et al., 2022b). Nguyen et al. (2022b) found that several psychological factors, such as attitudes, perceptions, and emotions, can influence food waste minimisation behaviour. Our user research confirmed this finding. To our question "What motivates you to find sustainable solutions for your kitchen?" we received responses such as "family's values", "the eco-conscious culture experienced in Finland", "influence of friends and society" and "social media videos". Perera et al. (2023) suggest that when promoting sustainable practices through technology, it is crucial to prioritize user needs rather than blaming the user for the problem. Based on the facts mentioned above, related studies and

user study conducted by us, we defined four experience goals and implemented a prototype of motivational software which exploits nudging.

Our assumption that financial incentives motivate users to reduce food waste was supported by previous studies conducted by Perera et al. (2023) and Nguyen et al. (2022). Our user research also confirmed this assumption, with five out of eight participants identifying economic considerations as their primary motivation for adopting sustainable practices. Based on these findings, we defined "financial safety" as one of the experience goals. Our user experience evaluation showed that this experience goal was successfully achieved, as all six participants reported increased financial awareness and a sense of security.

When considering what prevents us from living a sustainable lifestyle, we realise the importance of time. Previous research results by Nguyen et al. (2022) and Perera et al. (2023) show that older people are more likely to compost and adopt sustainable practices than young people. Presumably, the reason for this is the inconvenience cost caused by the lack of time. The user research we carried out also gave indications of this. One participant answered: "I wish it was made mode simple for consumers." to our question "How do you wish the sustainable solutions will help you in everyday life?". Based on this, we defined the experience goal as "a sense of efficiency and ease". This goal was achieved by all six participants involved in the user experience evaluation completing the tasks quickly and without problems. According to the participants, the user interface is intuitive and provides the user with sufficient instructions on how to use the application. However, the participants estimated that adding products manually is time-consuming and it was hoped to make it more efficient. This is even though we have already implemented a scanner in the application, with which products can be added quickly using the phone's camera, Optical Character Recognition (OCR) technology and machine vision.

In our user study, it emerged that the participants feel a sense of responsibility towards the environment. They also see their small sustainable choices as meaningful towards a better world. The participants hope that with the help of sustainable solutions, pollution will be reduced and thus the air quality will remain good, and the seasons will remain the same. To our question "How do you wish the sustainable solutions will help you in everyday life?" we got the answer "They'll just make me feel morally better that I'm not destroying the planet.". Based on the answers we received, we defined the experience goals as "a sense of achievement" and "a sense of Satisfaction". These goals were also achieved. Four of the six participants, particularly attuned to concerns about food waste and the environment, found the application to be a fitting solution and expressed a profound sense of satisfaction derived from meaningful actions contributing to a larger purpose.

Gram-Hanssen (2008) highlighted the fact that it is difficult for people to change their routines. For this reason, we included

gamification in the application and positively guided users towards more sustainable choices. Our goal is that initially potentially extrinsic motivation, such as social pressure or financial savings, becomes intrinsic motivation, i.e., the user feels e.g., great satisfaction because of his actions. Based on the user experience evaluation, this may be possible. Users were satisfied with the fact that they were provided with statistics about, for example, how much they save money by eating food instead of throwing it away. In addition, users were satisfied with the gamification. It was nice for them to see the face of the earth changing because it brings joy, it's cute and informative, and it brings a sense of gamification.

In conclusion, the participants who participated in the user experience evaluation were satisfied with the prototype. They found it to be useful especially in reducing CO_2 footprint, for sustainability purposes such as aiding to control food waste and saving money and in organizing items. One participant found the application useless because is lazy, and poor at using self-help apps. In addition, Participants described the prototype as interesting, straightforward, and user-friendly, expressing feelings of happiness, satisfaction, positivity, and curiosity while using it. According to our assessment, all the defined experience goals were successfully achieved, and we gathered positive feedback along with additional suggestions.

6.2 Limitations

There are several limitations to the generalizability and reliability of the results of our study, which are important to consider when evaluating the data and interpreting the results. First, the number of participants was very limited, only eight people, which may limit the generalizability of the results to wider population groups. The small group of participants does not necessarily represent diverse socio-demographic backgrounds, such as different age groups, genders, educational levels, or economic situations. This makes it difficult or even impossible to generalize about the behaviour and attitudes of different population groups.

In addition, although background information on participants was collected, certain important sociodemographic information was missing. For example, regarding gender, most participants were women, which may affect the generalizability of the results. Likewise, the influence of place of residence, such as urban or rural environment, on behaviour and attitudes remained somewhat unclear, as the participants mainly represented an urban environment. This may affect the application of the results to rural areas or smaller population centres. For example, bio-waste collection is mandatory in the city, but not in sparsely populated rural areas.

In addition, it is important to note that the participants may have been familiar with the authors of the study, which may affect the feedback received. This may have the effect that the quality of the feedback may be more positive than it would have been if it had been given by completely stranger participants. Such familiarity can distort the reliability and objectivity of the feedback.

Taking these limitations into account is key in the correct interpretation of the results and the assessment of matters outside the scope of the study. Although the study provides valuable information, it is important to recognize the impact of these limitations on the generalizability and reliability of the results more broadly.

6.3 Future work

For future work, the current features of the application could be useful for individuals attempting to adopt more sustainable lifestyles. However, to ensure long-term engagement, expanding the application's functionalities is crucial. One potential development area could be providing recipe suggestions based on the items users have added to the app, helping them utilize existing food items more efficiently and reduce food waste.

Furthermore, the app could offer users insights into the quality of added items, their environmental impact, and their contribution to the carbon footprint. For instance, it could provide feedback on how certain dietary choices affect the carbon footprint and suggest alternatives, such as substituting meat with fish while displaying the health implications of these choices.

Additionally, in line with our initial considerations, we would like to explore the possibility of collaborating with grocery stores to facilitate food ordering directly through the app. Interestingly, one participant during the User Experience Evaluation also suggested a similar idea: "Collaboration with something like the K-Ruoka app, so all the groceries would appear there automatically." Such collaboration could streamline the user process and automate the addition of purchased items.

The suggestions obtained from the user experience evaluation were valuable and offered insights for the app's enhancement. These included:

- A help button on the main page guiding users on adding or removing items in the kitchen.

- Capability to add or remove multiple items, including quantity.

- Automatic synchronization of grocery lists and changing the wording of the "report" feature for better clarity.

- An in-between tab allowing users to immediately scan food items.

- Simplifying the process of adding items without manual input.

- Integration of a freezer section within the kitchen.

- More visually appealing images of the planet and plants.

- A section showcasing other sustainable solutions, like thrift stores or food-sharing services.

- Enhanced sorting options and a search function for specific items on the list to streamline user experience.

7. REFLECTION OF GROUP WORK

Teamwork played a crucial role in the success of the project. Throughout the entire process, effective collaboration, sharing of tasks, and communication was essential. Despite not knowing each other initially, our team managed to work together smoothly, ensuring good execution of tasks and the overall success of the project.

Some of our bigger strengths among our team was diverse skills, with each member bringing unique knowledge along. For example, some team members were newer to using Figma, the tool used for creating our prototype, so having a member who had more experience with it proved to be extremely helpful. Our team also maintained an open mind when sharing ideas for the project, making ideation a pleasant and collaborative process. With only three members in our team, everyone's opinions were valuable, making it also easier to contribute to discussions compared to larger teams where one or two members might dominate the discussion.

We held weekly Teams-meetings, where we discussed progress, ideation, and other project-related matters. During each meeting, we also distributed the next tasks evenly among everyone. Our usual workflow mainly involved independent work on different sections of the text as well as various other tasks during the week. Outside of meetings, we communicated through Telegram to update on progress or ask additional opinions and questions. In the end, everyone contributed evenly throughout the process, did the assigned tasks and was present, resulting in a solid project. Fortunately, we didn't encounter any major challenges or communication issues, except for minor language barriers that we managed to overcome.

We aimed to distribute the workload of the report evenly so that each team member could work on preferred sections. Writing the report was a major part of the project, so next is listed the main responsibilities regarding this: Chinh focused on writing Chapter 3: User Study and its subchapters, and Chapter 5: Prototype Evaluation along with its subchapters. Kerttu handled the Abstract, Chapter 1: Introduction, Chapter 4.2: Prototype Design, and Chapter 7: Reflection of Group Work. Melina took charge of the remaining chapters: Chapter 2: Related Work and its subchapters, Chapter 4: Design Explained and subchapter 4.1, as well as Chapter 6: Discussions and all subchapters.

In addition to sharing the report writing workload, there were many other tasks which we either did collaboratively or individually. Everyone contributed to searching for literature references, and Melina compiled and wrote about them in her assigned chapter. We planned the initial user study survey together, and then searched for participants individually. Chinh took the lead in creating the form used for the user study. The ideation process for the product was overall a collaborative effort.

When designing proto wireframes, we assigned everyone with specific responsibilities: Melina worked on the Home page, Chinh focused on the Report page, and Kerttu handled the Kitchen page. In the high-fidelity design stage, each of us finalized our respective pages. We also collaborated by helping and offering suggestions for improvement on each other's pages, namely Chinh who was the most experienced in using Figma.

We collaborated on planning the prototype evaluation process together. Melina took the lead in formulating questions for the question-completion form, while Chinh was responsible for creating the forms used in the prototype evaluation. During the prototype evaluation, each team member independently found and interviewed two participants. Chinh primarily handled the data analysis for his chapters in the report. Kerttu took care of submitting the report in the various phases on time.

In the end, we aimed for an equal distribution of work, with each team member contributing roughly one-third of the work. We tried to balance tasks so that if someone took on more work in one phase, others would take on more in the subsequent phases. In the end, it felt like we achieved a point where everyone contributed equally, considering all the writing, designing, and various tasks involved.

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