An evaluation of the impact of gamification and digital nudges on household food waste reduction

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DECLARATION STATEMENT

I hereby certify that the material, which I now submit for assessment on the programme of study leading to the award of Master of Science, is entirely my own work and has not been taken from the work of others except to the extent of such work which has been cited and acknowledged within the text of my own work. No portion of the work contained in this research project has been submitted in support of an application for another degree or qualification to this or any other institute.

Kostandinos Hodaj

Date
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An evaluation of the impact of gamification and digital nudges on household food waste reduction

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Food waste is a pressing environmental challenge and households contribute greatly to the global waste. Recent research highlights the potential of digital applications to assist households in managing their food waste. Such applications use various means to entice the users to interact with them and reduce their food waste. Gamification and digital nudges have been shown to enhance user motivation and encourage behavioral change. This study aims to investigate whether the intrinsic motivation of users who cook at home can be improved using game elements and digital nudges. Initial research was conducted in the form of surveys, interviews, and competitor analysis. This informed the design of two prototypes. One prototype of the household kitchen app was created, and a second version of that prototype was made with game elements and digital nudges. Thirty participants were recruited for the user testing. They were divided into two groups of 15. Group A users interacted with prototype A which had game elements and digital nudges. Group B users interacted with prototype B which had no game elements nor digital nudges. All user tests in both groups were moderated. Pre and post-test IMI surveys as well as post-test SUS surveys were conducted in both groups. The findings suggest both prototypes significantly improved intrinsic motivation from the pre-test to the post-test. There were no statistically significant differences between Prototype A and Prototype B on any IMI subscale. Both prototypes have excellent usability but the slight difference in SUS scores is not statistically significant. It is expected that this research study will help other researchers better understand if implementing game elements and digital nudges are beneficial for the design of kitchen inventory management apps.

CCS CONCEPTS • User centered design • Interaction design • HCI design and evaluation methods

Additional Keywords and Phrases: Digital nudges, Gamification, Intrinsic motivation, Sustainability, Food waste, User engagement, Inventory list

1. INTRODUCTION

Food waste produced by households presents a critical environmental challenge. This kind of waste leads to the unnecessary depletion of nutritional resources and the release of extra greenhouse gases. A UN report published in 2019 calculates that food waste accounts for 8-10% of global greenhouse gas emissions [7]. They found that 931 million tonnes of food were wasted globally, with 61% coming from households. This suggests that 17% of total global food production is wasted and households are the main contributors accounting for 11% [7]. Other than being an environmental issue, a study from 2014 estimated that food waste costs the global economy about $936 billion a year [19]. However, reducing consumer food waste by 20%-25% by 2030 is estimated to save the world $120-$300 billion per year [15]. In both high and middle-income countries, food waste mainly occurs at the consumer level [7].

This research focuses on consumers in developed countries and the changes in their behaviour as a method to reduce food waste. It concentrates on the positive outlooks a smart kitchen app may have at minimizing the food waste of a household. The application is equipped with systems that nudge the users to make more ecological decisions and gamification features. A way to mitigate food waste is by nudging households to manage better their food inventory [12]. In addition, the application includes gamified features to engage users [6]. Also, to foster a competitive spirit, social connectivity with user points is implemented. The research focuses on the following two areas: analyzing the engagement of the users of this kitchen app, and assessing the urge of the users to act on digital prompts. This research utilises prototypes to test different features and value their effectiveness, mainly through user activity logs and post-interaction surveys. The System Usability Scale (SUS), and Intrinsic Motivation Inventory (IMI) are used to measure usability and user satisfaction, and motivation accordingly [14, 5].

The study starts with a literature review on current issues of households regarding food waste, causes, and solutions. Then it will explore the uses of gamification and digital nudges, and their advantages and how can they be used as solutions. It will then outline the methodology and design process used in order to address the research questions and related hypotheses. Finally, it will present the results of the experiment, discuss these findings, and conclude with a summary and suggestions for future work.

2. LITERATURE REVIEW

2.1.1 Food waste in the household

The amount of food waste that a household produces is a significant environmental concern. It contributes to unnecessary resource consumption, which leads to an increase in greenhouse gas emissions. It is argued that globally, 931 million tonnes of food is wasted, with 61% coming from households [7]. Research shows that the main challenges households face when it comes to the effective management of their food inventory are limited awareness of the issue, lack of planning, and the customers' purchasing behaviours [16]. Research findings indicate that there are ways to combat this excessive food waste. As Gustavsson et al. suggests, in industrialized countries, households need to be educated on the issue of food waste and then start to make changes in their consumption behaviour [10]. Technological innovations, such as an app that tracks sustainable consumption and offers kitchen guidance, may positively impact households to reduce food waste [4]. By helping users manage their inventory and plan meals, such apps may promote more sustainable consumption practices [4].

2.1.2 Causes of food waste

Consumer behaviour and awareness play an essential role in food wastage [20]. Goodwin states that consumers lack the knowledge to correctly store food or plan meals [15]. She says that marketing strategies and poor product packaging often also contribute to food wastage. He also states that cultural norms and economic status can profoundly influence an individual's purchasing and consumption habits. Some events based on tradition or religion can lead to a surplus of food that is often not consumed and later thrown away [13]. Unsustainable buying habits such as impulse buying and bulk purchases have also been identified as contributors to food wastage [22].

2.1.3 Ways to reduce food waste

Some ways to manage food waste are the following: awareness campaigns [16], digital nudges [8], motivations [20, 1], framing effect [21], and technology [17]. Education and awareness campaigns help advise consumers regarding the consequences of food waste and possible ways to reduce waste [16]. Digital nudges in digital experiences can be used to fight food waste as they can take the form of reminders that urge consumers to adopt a more ecological approach to food consumption [8]. Researchers have suggested the use of motivations and punishments, such as in the form of monetary prizes for reduced waste or fines for increased waste, which is also considered a solution to reduce food waste [20, 1]. The framing effect is defined as the bias where people react differently to a particular decision depending on how it’s presented, or “framed”, emphasizing either the positive (gain) or negative (loss) aspects. The same information, when framed differently, can alter people’s responses [24]. It also helps in reducing food waste and it works by presenting information in a way that shows the benefit of reducing food waste [21]. Likewise, technology in the form of digital applications also helps mitigate the issue by helping people track and manage their food stocks [17].

2.2.1 Using technology to combat food waste

Food waste is a growing global phenomenon that leads to major environmental and economic issues. Improper food planning, poor storage practices, and the failure to consume purchased items before they expire are big contributors to this problem [2]. Food waste does not only cause the loss of valuable resources

but it also leads to an increase in the carbon footprint due to the production and disposal means [18]. Households find it difficult to make the most out of the products they buy. The problem is worsened by them not making grocery lists and not keeping track of product expiration dates [2].

The gamification of a digital experience and the use of digital nudges in the context of technology can be used to reduce excessive food waste. Gamification is the process of incorporating game elements into digital contexts to boost user engagement and motivation [6]. According to researchers, gamification can encourage consumers to adopt proactive measures including creating grocery lists, managing expiration dates, and optimizing product usage [6]. As an example, gamified applications may encourage users to create meal plans and suggest recipes for products that are about to expire. Gamified systems may also encourage user involvement by including elements like connecting with friends, goal setting, and friendly competition like they are used in popular apps like Duolingo and Google Maps [11]. Additionally, digital cues like alerts and reminders might encourage consumers to use products from their pantry or offer substitutes for items that are about to expire [12].

2.2.2 Gamification

Gamification is the process of adding games or game-like elements to something (such as a task) so as to encourage participation. Gamification has been shown that it can motivate users and help them stay committed to a task [6]. By including gamified elements (reward points, badges, leaderboards, and progress bars), an application may effectively engage users to adopt healthier consumer practices and remain actively involved in managing food inventory. This may lead to a decrease in the food wastage produced by a household. Utilizing friendly challenges, as Duolingo does, places users under peer influence [11]. This leads to a sense of accomplishment and keeps them working on their goal [11].

Some beneficial gamified elements to be considered for a kitchen household application would be the following: collecting experience points, connecting with friends, and progress tracking. A reward system based on food saved can be included to assist users in being motivated. This can be designed to provide experience points when completing their objectives, which may lead to optimized food utilization, which in turn will lead to food waste minimization. Including components that allow users to interact with friends is another beneficial idea [3]. Users may compete with their peers in daily competitions on leaderboards, which might give them a sense of achievement. As a result, they may be more motivated to maintain their meal-planning goals [3]. Also, food waste may be reduced when users adopt a disciplined approach to food management with the support of progress-tracking widgets. Badges are allocated to users based on their individual progress as a reward to signify accomplishments or milestones which may increase motivation and engagement.

2.2.3 Digital nudges

Digital nudging is the use of user-interface design elements to guide user behaviour in a subtle way. Digital nudging methods can be used to affect user behaviour [12]. Reminders and notifications are some such techniques. Using them in a household kitchen application may lead to a reduction in food waste. This can be achieved by reminding users to consume pantry items before they expire. Proposals of alternative recipes based on available ingredients can be sent to the user from time to time aiming to make them use ingredients that are about to expire.

Nudges can be used to urge the user to alter their behaviour to a more sustainable one. To minimize food waste on an individual level, reminders and notifications to consume long-stored items in the pantry may be

sent to the users. Having the application offer alternative recipes based on the user's dietary preferences but with ingredient nearing their expiration date can also help reduce their wastage. Those alternative recipes could come from the community which can encourage the creative use of existing ingredients and lead to further prevention of unnecessary wastage.

2.2.4 Automated lists

Some supermarket chains provide digital receipts to their customers. These receipts are automatically logged to the customers' private accounts. The receipts may automatically be sent to the app to auto-populate food inventory lists. The automated food inventory lists spare the users from the manual task of inputting each product, thereby saving time. This process is a quick way for the users to monitor the food inventory which not only simplifies an aspect of the users' daily routine but may also help the user adopt a more organized approach to food management. Keeping track of one's food inventory makes people more aware of their available food items [23]. Thus, food inventory lists reduce food waste by preventing users from overbuying [23].

2.3.1 Research problem

The use of technological innovation as an effective way to mediate food waste has already been researched [17, 8, 6, 12] . It has been shown that it can positively impact users' behaviour, leading them to make sustainable choices. However, there is a need for more studies that look at a tailored approach to gamification and digital nudging. There are fewer studies on gamification and digital nudging for sustainability when compared to other fields. The scope of this research is to provide further findings in the field. It will focus on measuring user satisfaction and motivation levels in regards to sustainable cooking deriving from gamified elements and digital nudges.

2.3.2 Research questions

As part of the study, the following questions are intended to be explored and addressed.

Research question 1 (RQ1): How much does including gamified elements in a kitchen app motivate users to reduce their food waste by cooking more sustainably?

Research question 2 (RQ2): How motivated are users to engage with a cooking app when prompted by reminders or recipe suggestions?

2.3.3 Hypotheses

To address the research questions the following two hypothesis were created.

Hypothesis 1 (H1): Integrating gamified elements in Prototype A will increase user motivation to take up sustainable cooking and lead to a more effective food waste reduction compared to Prototype B which has no such features.

H1 Null: There is no difference in the levels of users' motivation to take up sustainable cooking between the two versions of the app.

Hypothesis 2 (H2): Reminders and recipe suggestions in Prototype A will improve the motivation of users to engage with a cooking app more than in the case of Prototype B which has no digital nudges.

H2 Null: There is no difference in the levels of users' motivation to engage with either version of the app.

3. METHODOLOGY

This study aims to examine whether game elements and digital nudging have a positive effect on the motivation of users to cook more sustainably with the help of a food management app. This chapter sets out the research methodology that was used to answer the above questions. There are many different user research methods available that can help understand a user's interaction with an app. This research focuses on the field of user experience and thus takes a user-centered approach. The methodology that will be used in this research is the Design Thinking methodology (Figure 1) which consists of 6 phases: empathize, define, ideate, prototype, test, and implement.

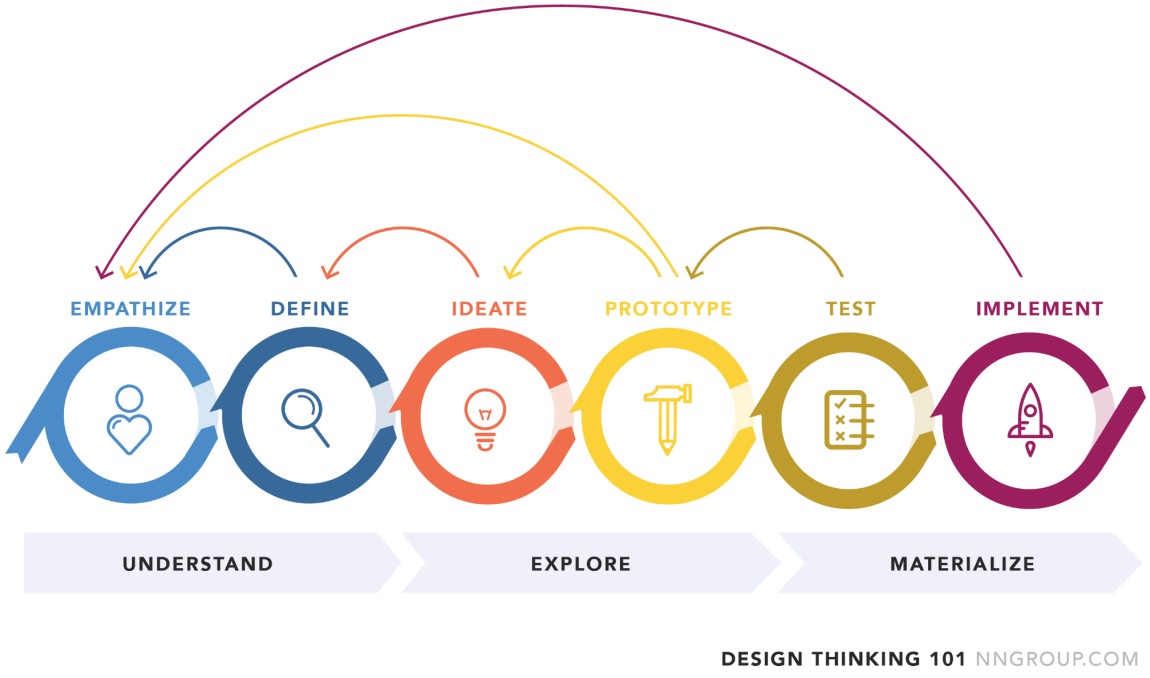

Figure 1. Nielsen Norman Group. Design Thinking 101 (July 31, 2016). Retrieved from https://www.nngroup.com/articles/design-thinking/

3.1 Empathize

The focus for this stage is on understanding the needs and pain points of the users. For this reason, interviews and surveys were conducted. The main aim is to develop a strong empathy for the users' challenges. The goal of this phase is to identify research gaps, learn about real user behaviors, needs, and mindsets, discover best practices, and identify gaps in the market. The generated data of this phase are: quantitative and qualitative data, content analysis, and literature review. The techniques used in this phase

are: literature review, questionnaires, and interviews. A mixed-method approach was used to gather both qualitative and quantitative data. All artefacts created in this stage can be found in appendix B.

3.2 Define

The goal of this phase is to define key user problems and needs that result from user research. The generated data of this phase are: visual and textual artefacts, and content analysis. The techniques used in this phase are: personas, empathy maps, and user journey maps. The themes presented are analyzed to find any best practices which could be implemented into the project. Quantitative and qualitative findings and insights helped to understand behaviour and motivation by identifying the needs and goals of the users. The findings informed personas, empathy maps, and user journey maps. All artefacts created in this stage can be found in appendix C.

3.3 Ideate

The next step in the design process is brainstorming a range of possible solutions to the issue. During this phase, the goal is to explore and iterate on possible design solutions that will address the core user problems. The generated data of this phase are: visual artefacts, and content analysis. The techniques used in this phase are: competitor analysis, competitor visual analysis, and app site map. All artefacts created in this stage can be found in appendix D.

3.4 Prototype

In this stage, low-fidelity prototypes were created. The prototypes were initially in the form of paper prototypes to help foster creativity instead of focusing on the visuals. Afterward, the prototypes became interactive and were tested with users. The goal of this phase is to create prototypes, and test and iterate in order to finalize a design for user testing. The generated data of this phase are: visual artefacts, qualitative feedback, and content analysis. The techniques used in this phase are: mood boards, brand identity, paper prototypes, mid-fidelity prototypes, high-fidelity prototypes, and pilot tests. During this stage, testing with users commenced as a way to catch any design shortcomings that may affect the user experience as well as gain user feedback to address before the final iteration. All artefacts created in this stage can be found in appendix E.

3.5 Test

In this stage, the goal is to validate and answer the research questions and hypotheses. The generated data of this phase are: qualitative and quantitative data, and content analysis results. The techniques used in this phase are: A/B testing, moderated remote and in-person user tests, IMI and SUS surveys, interviews, and content analysis. All artefacts created in this stage can be found in appendix F.

3.6 Implement

In this stage future work and beneficial amendments are discussed to be performed on the final product based on the conclusions reached in the previous phase. All artefacts created in this stage can be found in appendix G.

3.7 Recruitment

For the final experiment, a total of thirty participants were recruited. No pre-requisite demographic information was required of participants, so a screener was not conducted. Participants were recruited via personal networks, the university, and via social media. Before the testing, the participants were asked to confirm that they were over the age of 18. No personal, identifiable data was collected. The participants were all informed

about the purpose of the test, and how the data would be handled, and were informed that they could choose to end the test at any time they wanted.

3.8 Instruments

Two versions of the smart kitchen application were developed. Each has distinct characteristics. To test hypothesis 1, prototype A incorporates gamification elements. These were in the form of reward points, badges, leaderboards, progress tracking, and connecting with friends. Nudging features were also added to test hypothesis 2. These were reminders to consume pantry items, recipe suggestions based on items nearing their expiration date, and tips on optimal storage. On the other hand, prototype B was void of any gamification and nudging elements.

The System Usability Scale (SUS) was used to assess usability and the Intrinsic Motivation Inventory (IMI) was utilized to measure the level of motivation and engagement [14, 5]. Pre- and post-interaction surveys and interviews were utilized to collect data that helped assess user satisfaction.

3.9 Procedure

At the start, every participant was given an introduction to the study and what they should expect from the user testing. Before the testing, participants were asked to fill out an Intrinsic Motivation Inventory (IMI) survey. During the testing, participants were made to complete four tasks and interact with either Prototype A or Prototype B. After the test, participants were asked again to complete the IMI survey and provide feedback through surveys and interviews.

3.10 Data analysis

The study used t-tests to help interpret the scores. Paired sample t-tests were performed to measure within-group changes for each version of the prototype. Independent samples t-tests were performed to measure between-group comparisons between the two prototypes. Qualitative analysis was conducted using thematic analysis of information collected from the post-test interview responses for each group.

3.11 Ethical considerations

The research topic does not present any significant ethical concerns. Careful attention was given to the handling of participants' personal data and potentially sensitive information. Participants received clear guidance on the ethical principles. They were informed that both the interviews and the usability testing could be halted at their choice, and their consent to participate in the research could be withdrawn at any point should they choose to do so. Complete anonymity was ensured. They were assigned a participator's number for reference reasons and were provided the e-mail address of the host for future contact in case they had questions regarding the research or if they wanted to withdraw their participation and have their data erased.

4. DESIGN

This section will examine the key findings from the user research and how the insights were employed in an iterative design process.

4.1 Empathize stage findings

4.1.1 Survey

An online survey was conducted in order to collect quantitative data directly from a large pool of participants. The survey was then distributed via social media. In total 50 responses were collected.

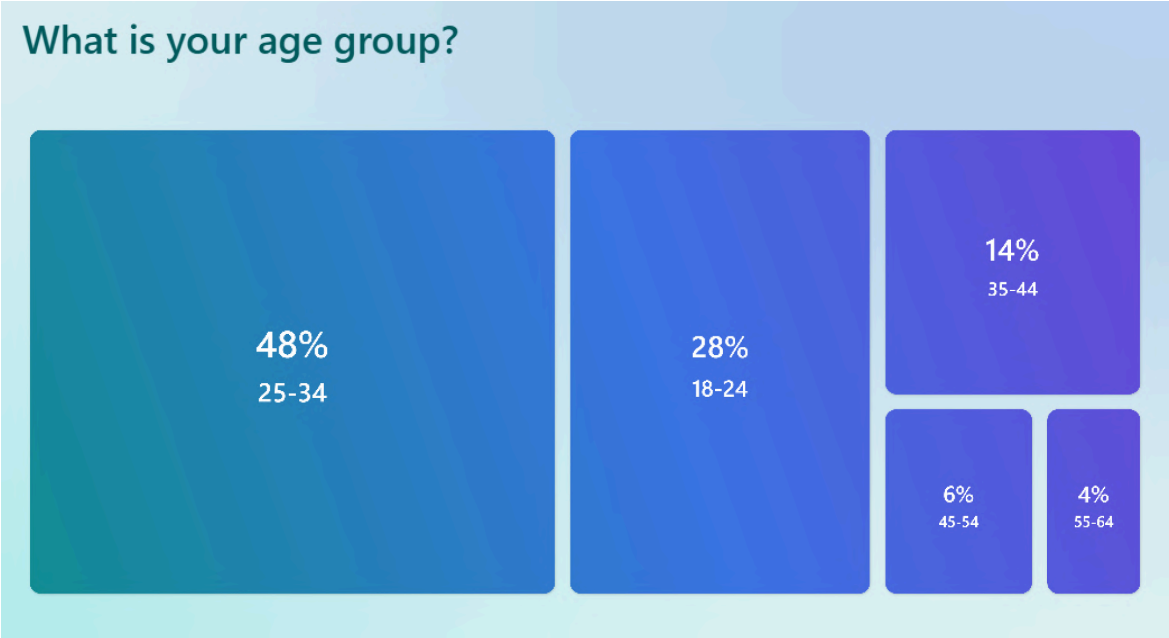

Figure 2. A chart showing the breakdown of age groups in survey participants

The survey and its data can be found in appendix B2, B3, and B4. Through the survey, it became apparent that the most common age group of the participants was 25-34 (Figure 2) with 18-34 being the 76% of the participants. This shows that younger adults might be more interested in eco-oriented issues. Regarding the frequency of food waste, monthly (40%) is the most frequent response for how often food is thrown away which means people don't throw food away often. Fruits and vegetables (74%) are most commonly thrown away meaning that fresh produce is challenging for most to store or consume in time. Regarding the meal planning habits of the participants, weekly (60%) was the most common answer suggesting that many respondents plan meals to some extent. Most respondents said they only buy a few items on impulse (60%) and only 10% acknowledged they impulse buy every time they go shopping. This means that most young adults must be sticking to a predetermined list of items. The vast majority rely on manually checking (70%) their food inventory. However, 84% of participants said they throw food away on a monthly, yearly basis, or even never. This means that even without lists most participants are able to handle their food inventory quite well. The most common challenges were forgetting items (70%) and lack of time (50%) (Figure 3) which hint at behavioral and time management issues.

Figure 3. A bar chart showing the challenges participants of the survey face preventing food waste

When asked what feature they would prefer in a food managing app, expiration date reminders (41%) were the most requested feature. The majority of participants are open to the use of an app (44% yes, 40% maybe) to help manage food inventory and reduce waste. Only 2% of the participants said they use an app to help with their food inventory, yet 84% of all participants say they are open to the use of such an app on various levels. This might suggest that a big part of the participants were not aware of the existence of such apps. On the other hand, participants showed mixed feelings towards social elements. Only 28% viewed it as positive in contrast 36% disliked the idea with the remaining 36% of the participants not being sure about it. When it came to motivation, most respondents are very motivated (54%) or somewhat motivated (40%) to reduce food waste. This indicates a clear interest of young adults in the issue of food waste.

Insights from the survey:

- Behavior mostly forgetfulness and lack of planning contribute to food waste.
- There is a clear interest in using apps and reminders to manage food inventory.
- Fruits and vegetables are a big pain point. (backed by interviews)
- Respondents share a positive view toward tools that can help them live more sustainably.

4.1.2 Interviews

Seven semi-structured interviews of one closed-ended and nineteen open-ended questions were conducted with participants who cook at home. The interviews were conducted to help understand participants' perspectives. Four interviews were conducted online and three in person. The aim of these interviews was to gather qualitative data and insights [35].

The interview questions and the answers can be found in appendix B5, B6, and B7. Thematic analysis was used to identify patterns [25]. Vegetables, fruits, dairy, cooked meals, and meats were identified as commonly wasted foods (Figure 4). Spoilage and over portioning were among the causes of wested foods.

Figure 4. Illustration of food categories identified as contributors to household food waste

Many participants said they forgot items in the fridge or pantry until they expired. And cooking large portions made them throw some food away. Regarding the behaviors of the participants, most of them either kept mental tabs or checked their food inventory manually. Vegetables were a common frustration because they go bad easily. When it comes to meal planning, participants said they do weekly shopping with minimal use of lists. Most participants avoid overbuying by sticking to essentials or always buying the same stuff. When questioned regarding potential solutions, all participants viewed expiry date reminders positively. Recipe suggestions to use up leftover ingredients were also viewed positively by most. On the other hand, social elements showed mixed opinions. When asked what would motivate them to reduce food waste, most participants said awareness of hunger in others motivates them to reduce food waste. They also noted sharing food with others as a solution.

The following are recurring themes emerging from the interviews:

- Frustration with easy to spoil fresh food, especially with fresh produce.
- Desire for assisting tools like reminders, recipe suggestions, and storage tips.
- Many participants show sensitivity toward others referring to often sharing leftover food with friends.
- Cooking big portions often leads to food waste.

4.2 Define stage findings

4.2.1 Personas

Two personas were created to show who the key users are for the food management app. Personas are thorough descriptions of standard users of the product that designers use to help them focus on and design the product based on the needs of such users [26]. The two key user groups identified were: young adults interested in sustainable practices, and adults with limited free time who want to focus on saving money and food in an easy and quick way.

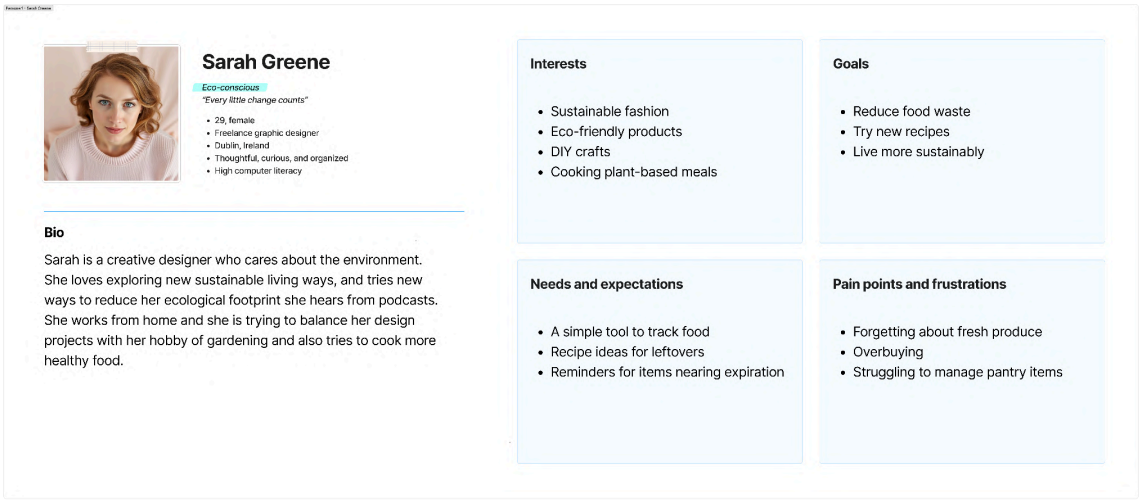

Figure 5. Primary persona Sarah Greene

The primary persona can be found in appendix C1. The primary persona is Sarah Greene (Figure 5). Sara is an eco-conscious individual. She is a 29-year-old young adult from Dublin, Ireland. She works as a freelance graphic designer. She is thoughtful, curious, and organized and has a high computer literacy. Sarah is a creative designer who cares about the environment. She loves exploring new sustainable living ways and trying new ways to reduce her ecological footprint she hears from podcasts. She works from home and she is trying to balance her design projects with her hobby of gardening and also tries to cook more healthy food. Her interests are: sustainable fashion, eco-friendly products, DIY crafts, and cooking plant-based meals. Her goals are: to reduce food waste, try new recipes, and live more sustainably. Her needs and expectations are: a simple tool to track food, recipe ideas for leftovers, and reminders for items nearing expiration. Her pain points and frustrations are: forgetting about fresh produce, overbuying, and struggling to manage her pantry items.

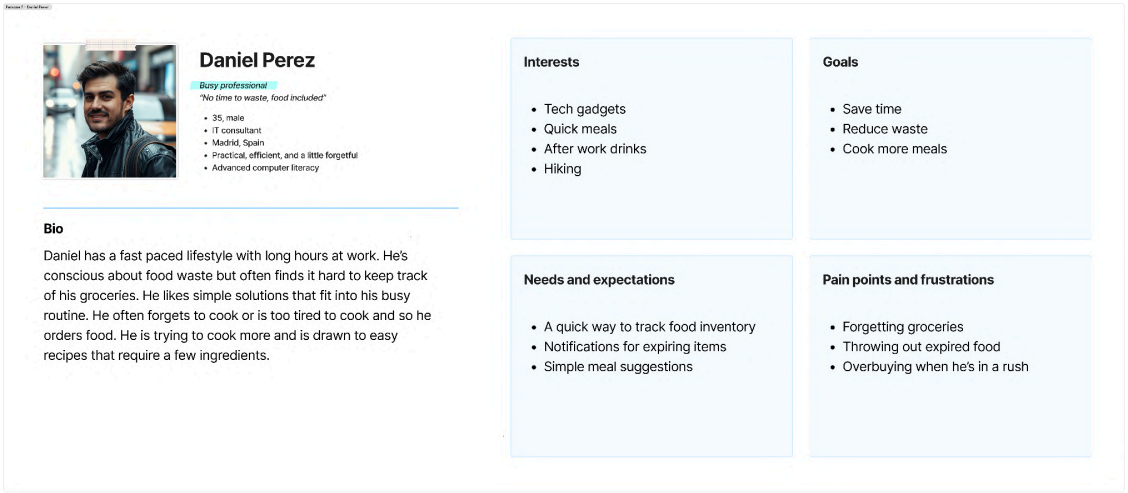

Figure 6. Secondary persona Daniel Perez

The secondary persona can be found in appendix C2. The secondary persona is Daniel Perez (Figure 6). Daniel is a busy professional. He is a 35-year-old adult from Madrid, Spain. He works as an IT consultant. Daniel's character is practical, efficient, and a little forgetful. He has advanced computer literacy. Daniel has a fast-paced lifestyle with long hours at work. He's conscious about food waste but often finds it hard to keep track of his groceries. He likes simple solutions that fit into his busy routine. He often forgets to cook or is too tired to cook and so he orders food. He is trying to cook more and is drawn to easy recipes that require a few ingredients. His interests are: tech gadgets, quick meal ideas, after-work drinks, and hiking on weekends. His goals are: to save time, reduce his waste, and cook more meals at home. His needs and expectations are: a way to quickly track his food inventory, notifications for expiring items, and simple meal suggestions. His pain points and frustrations are: forgetting groceries for too long, constantly throwing out expired food, and overbuying.

4.2.2 Empathy maps

To further empathize with the users, empathy maps were created for each persona. Empathy maps are used to visualize user feelings and thoughts. They help UX teams to develop deep, shared understanding and empathy for other people [27].

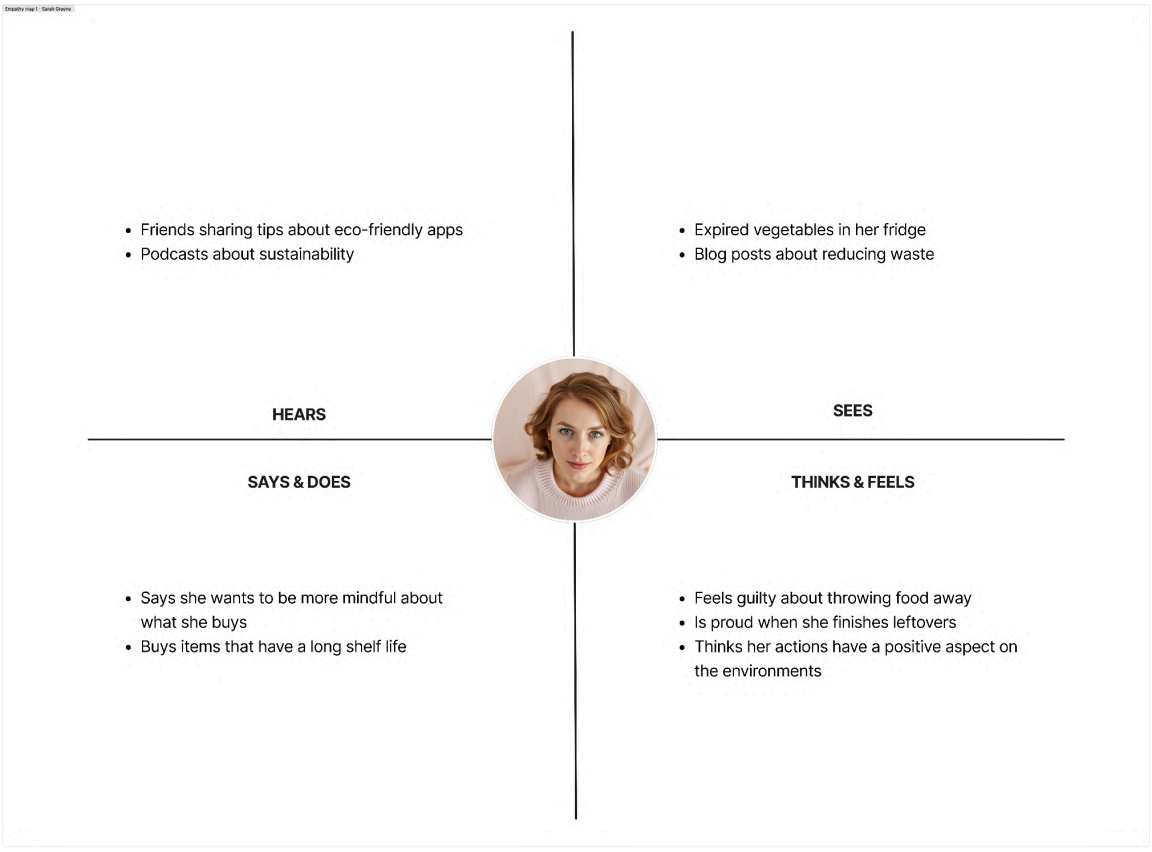

Figure 7. Empathy map for Sarah Greene

Sarah's empathy map can be found in appendix C3. For Sarah's empathy map (Figure 7), Sarah hears: Friends sharing tips about eco-friendly apps and she listens to podcasts about sustainability practices. She sees: expired vegetables in her fridge and follows a blog on the topic of reducing waste. She says she wants to be more mindful about what she buys and buys items that have a long shelf life. She feels guilty about throwing food away and is proud when she finishes leftovers. She thinks her actions have a positive effect on the environment.

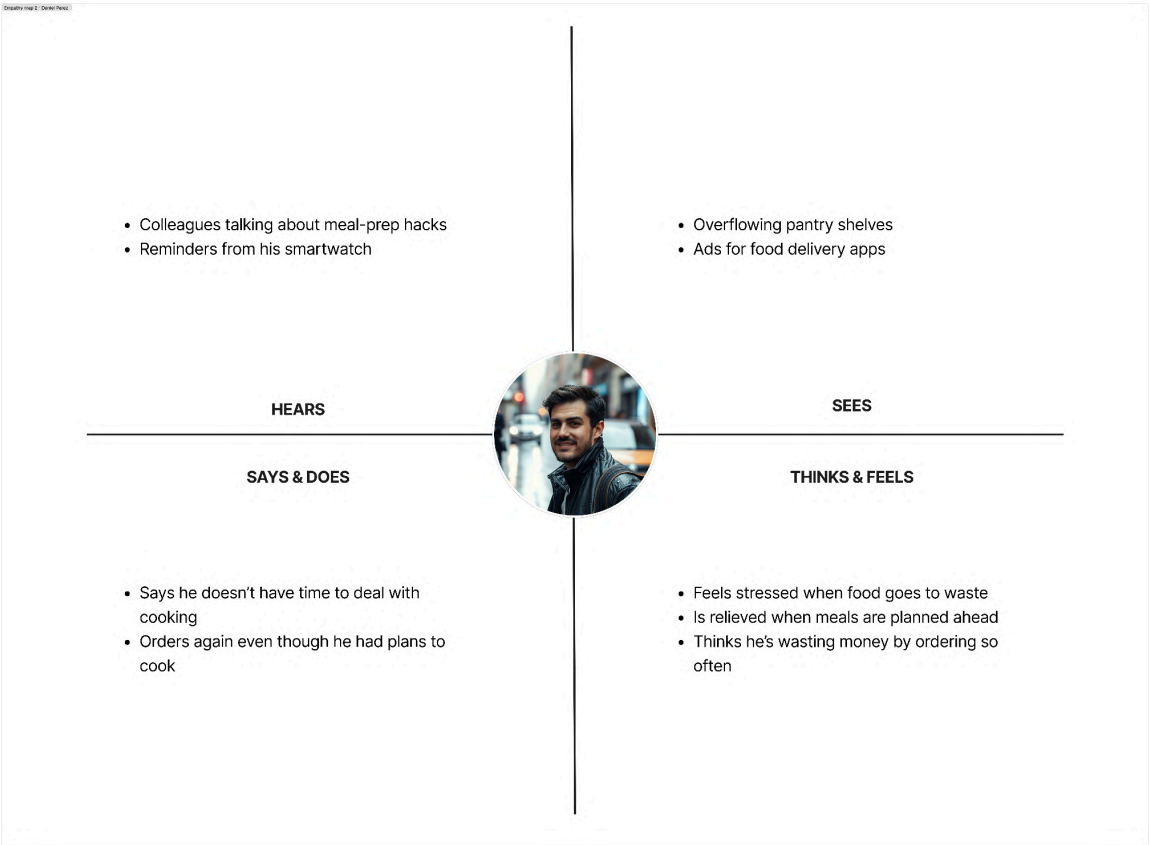

Figure 8. Empathy map for Daniel Perez

Daniel's empathy map can be found in appendix C4. For Daniel's empathy map (Figure 8), Daniel hears colleagues talking about meal-prepping hacks. He constantly receives reminders on his smartwatch. He sees: his overflowing pantry shelves with expired food, and sees ads for food delivery. Daniel says he doesn't have time to deal with cooking so he orders again even though he had plans to cook. He feels sad when food goes to waste and is eased when meals are planned ahead.
He thinks he's wasting money by ordering so often.

4.2.3 User journey map

User journey maps were created for each persona. User journey maps illustrate the steps a user goes through in engaging with a service, revealing pain points that can inform designers and help them better understand the user's experience [28].

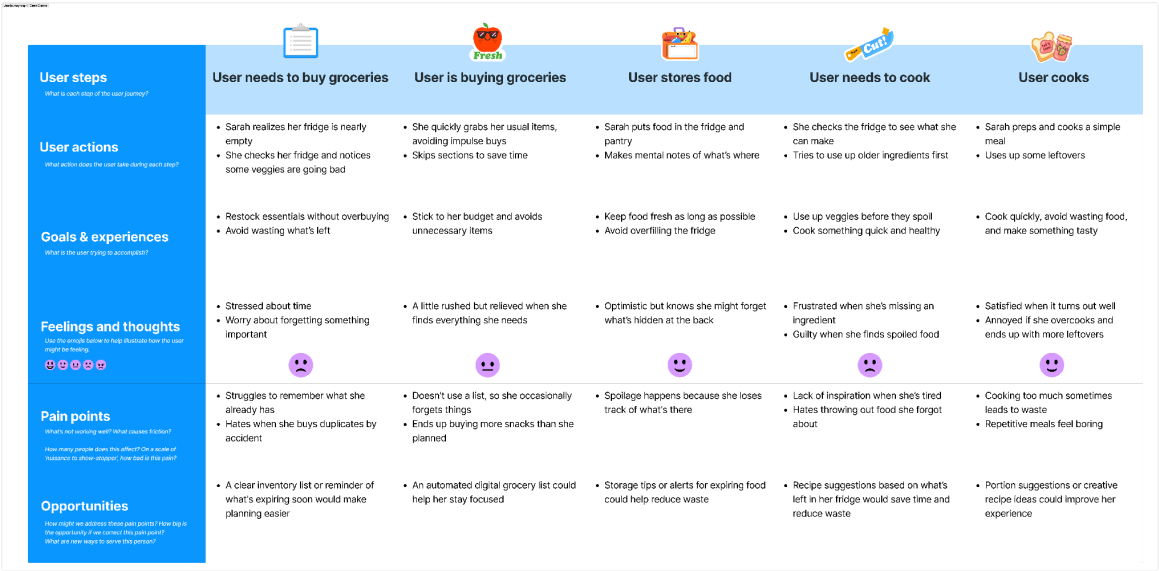

Figure 9. User journey map for Sarah Greene

Sarah's user journey map (Figure 9) can be found in appendix C5. Sarah goes through the following steps:
1. User needs to buy groceries.
2. User is buying groceries.
3. User stores food.
4. User needs to cook.
5. User cooks.

Takeaways from the user journey map are the opportunities for features to be implemented in the app. For Sarah, those would be:
1. A clear inventory list or reminder of what's expiring soon would make planning easier.
2. An automated digital grocery list could help her stay focused.
3. Storage tips or alerts for expiring food could help reduce waste.
4. Recipe suggestions based on what's left in her fridge would save time and reduce waste.
5. Portion suggestions or creative recipe ideas could improve her experience.

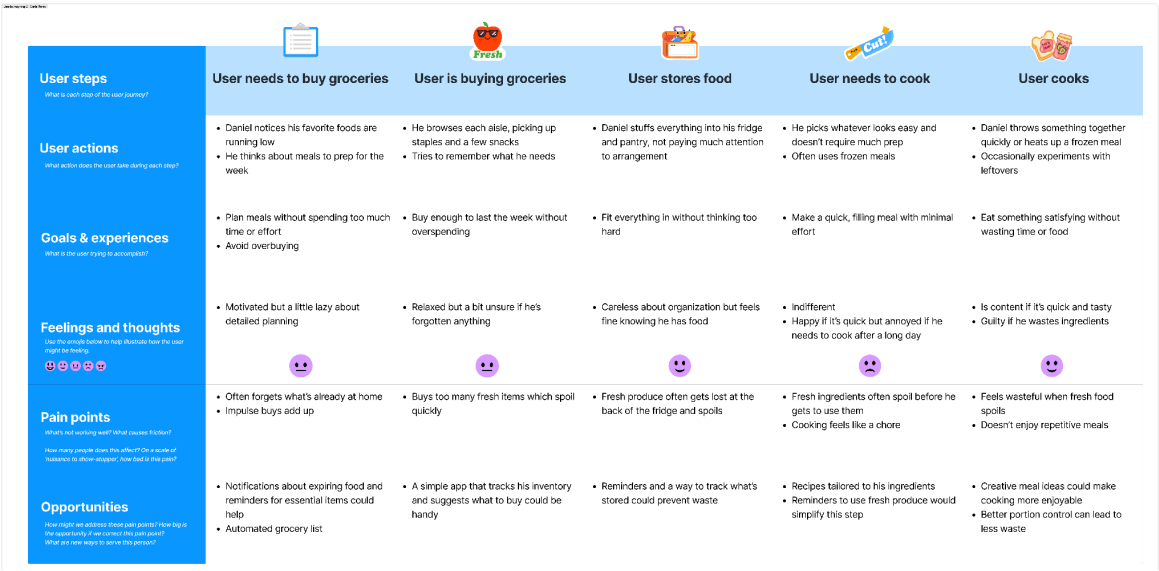

Figure 10. User journey map for Daniel Perez

Daniel's user journey map (Figure 10) can be found in appendix C6. Daniel goes through the following steps:
1. User needs to buy groceries.
2. User is buying groceries.
3. User stores food.
4. User needs to cook.
5. User cooks.

Takeaways from the user journey map are the opportunities for features to be implemented in the app. For Daniel, those would be:
1. Notifications about expiring food and reminders for essential items could help. Automated grocery lists.
2. A simple app that tracks his inventory and suggests what to buy could be handy.
3. Reminders and a way to track what's stored could prevent waste.
4. Recipes tailored to his ingredients. Reminders to use fresh produce would simplify this step of cooking.
5. Creative meal ideas could make cooking more enjoyable. Better portion control can lead to less waste.

4.3 Ideate stage findings

4.3.1 Competitor analysis

A competitor analysis was performed on gamified applications that make use of digital nudges. Reviewing related products and systems helps to identify market best practices, and usability methods but also areas where a product can stand out [29]. Competitor analysis was conducted on the following three apps: Duolingo, Google Maps, and Forest App. All competitor analysis can be found in appendix D1.

The following similarities were identified:

- Earning points and badges.
- Visual progress tracking.
- Reminders.

- Social features.

The key takeaway from the competitor analysis is that apps in the market use setting goals and giving rewards as a way to motivate users. They also use reminders/ nudges at a level that feels helpful and not intrusive. The following were identified as possible features that create value for the app:

- Rewards: a visual representation of saved food, supermarket vouchers.
- Nudges: reminders about expiring food, tips on proper food storage.
- Community: progress sharing and recipe suggestions from other users.

4.3.2 **Competitor visual analysis**

A visual analysis was conducted on all three apps, Duolingo (Figure 11), Google Maps, and Forest App. This helps identify the visual identity of the competitors and how they choose to visualize the game elements and the instances of digital nudges they use in their apps. The visual analysis can be found in appendix D2.

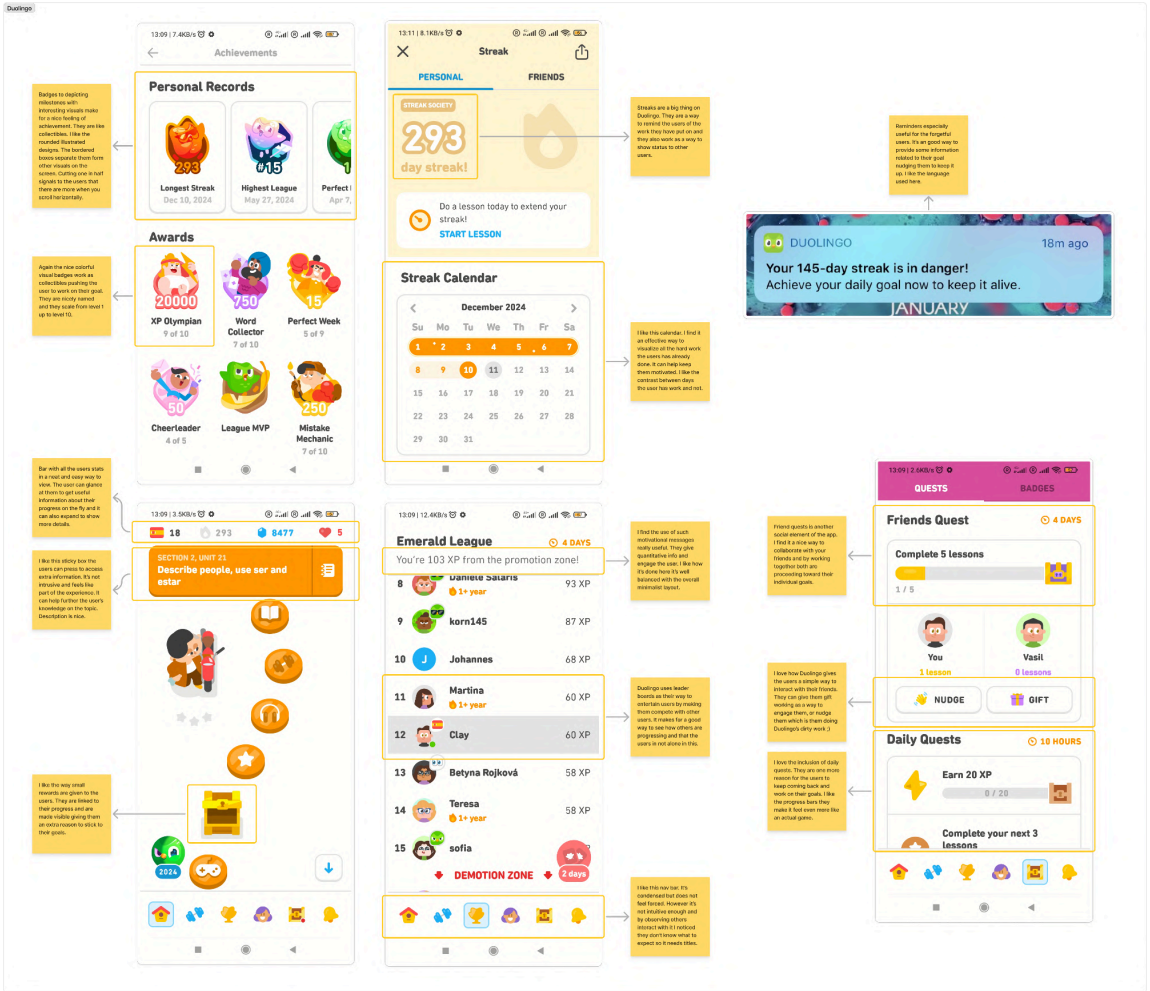

Figure 11. Visual analysis of Duolingo app

From the visual analysis, it became evident that all three competitors chose to reward users with badges and collectible points (Figure 12). The badges are illustrated and feel like a prize won from a game. The aesthetics of the apps hint at a video game style. The apps have rounded shapes with as few sharp corners as possible. Shapes are minimal and the colors are vibrant.

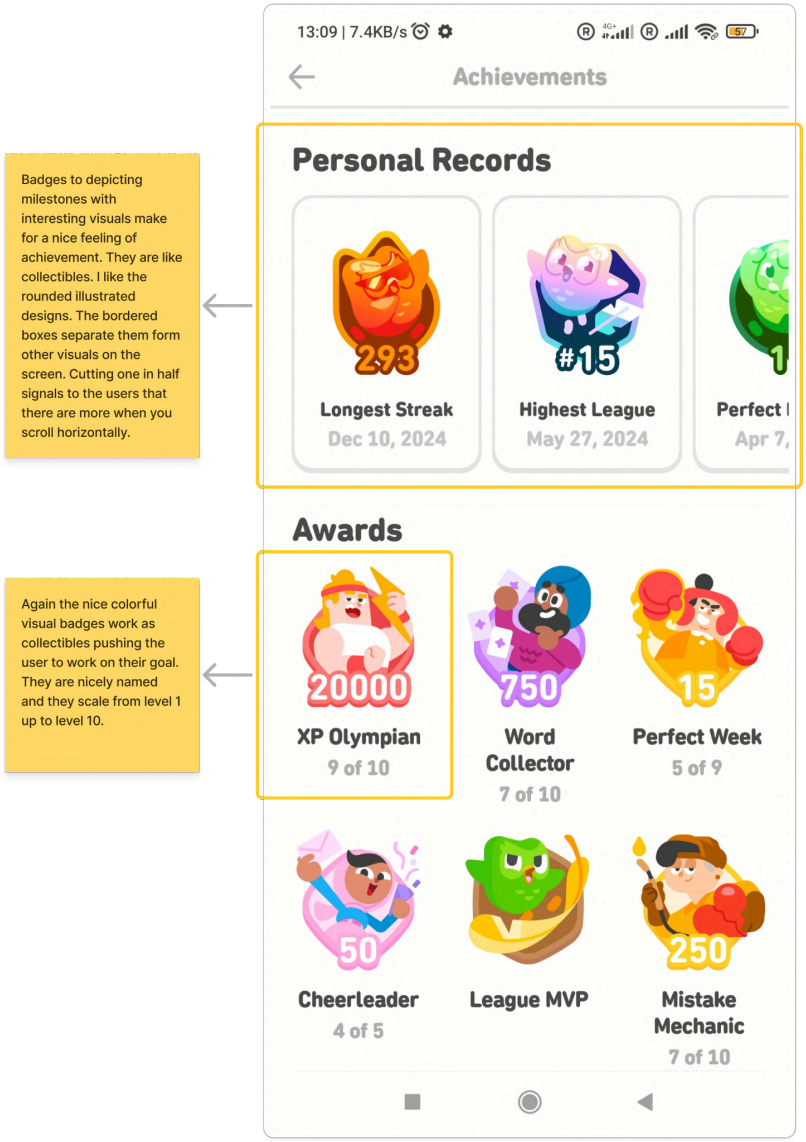

Figure 12. Visual analysis of Duolingo's badges

Regarding digital nudging, all apps have a mix of motivational text and reminders. Reminders extend also outside of the use of the app so users receive reminders in the form of notification in their phone at any time. Statistics of the user's progress are presented frequently. The tone of voice is cheerful and playful.

4.3.3 App site map

An app site map is a visual representation of the app's architecture, its screens, and their relationships [30]. An app site map of the app was created and it can be found in appendix D3. The app was divided into five sections: Home, Inventory, Meals, Social, and Profile. Each section serves a different need. Home is where users can track their progress, find their stats, receive motivational messages, and get tailored tips. On Inventory, users have access to their food inventory which they can edit, and also receive notifications regarding the status of their food items. On Meal, users can plan their meals, and get recipe recommendations based on the status of their food and dietary preferences. Social is where users can view updates regarding the progress of their friends, interact with other users, post updates, share recipes and food, and initiate friend challenges. In Profile, users have access to their personal information, sync other apps, view data on their progress, and receive help.

4.4 Prototype stage findings

4.4.1 Mood board

A mood board with many other similar apps was created to help establish a visual language. A mood board is a collection of visual materials that evoke a certain style or concept [31]. Yang (2023) says that in UX design, mood boards are used to visually show the feelings or values that the digital product should create. Typically, mood boards are used to define the product's primary UI colors and the visual design identity [31].

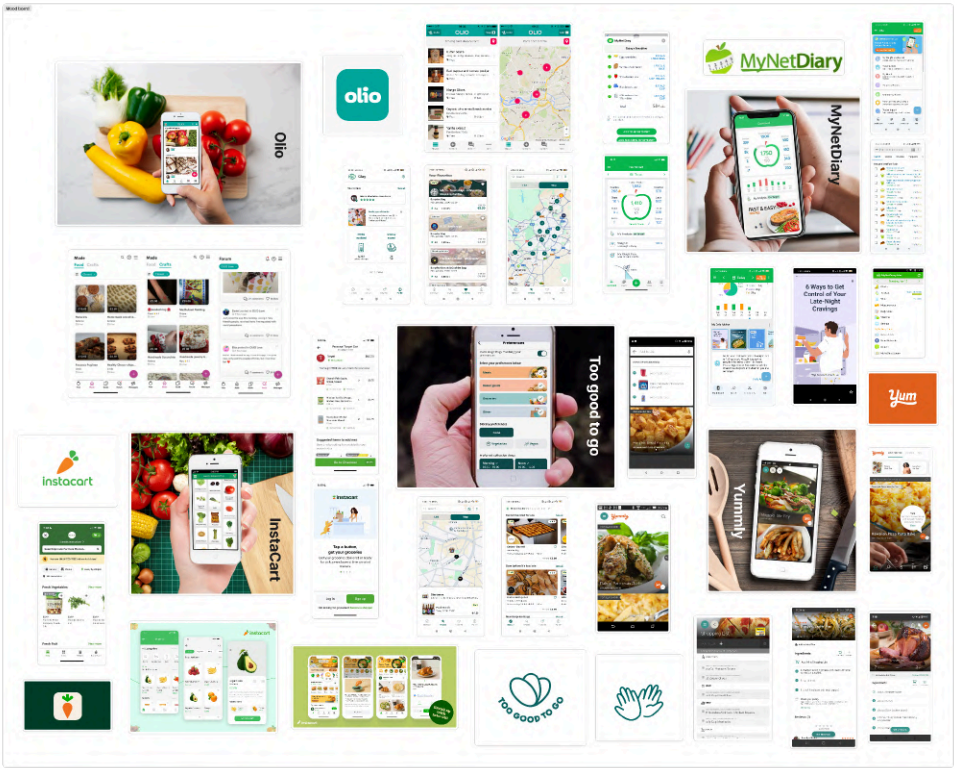

Figure 13. Mood board with similar apps

Images and videos from similar apps like InstaCart, Olio, Too Good to Go, MyNetDiary, and Yummly were used to synthesize the mood board (Figure 13). Through the mood board, it is possible to perceive that the app aims to feel like a friendly, modern, positive, and helpful tool for eco-conscious people who want to cook more sustainably. The mood board for the app can be found in appendix E1.

4.4.2 Branding

According to Kaplan (2016) brand is a subjective perception of value based on the sum of a person's experiences with a product or company that ultimately influences that person's sentiment and decisions in the marketplace [32]. To establish identity and ensure consistent user experience a brand was designed for the app. A name, logo, tone of voice, colors, typography, and iconography were studied and assigned to the brand image of the app. The app was named Savr and its slogan is less waste, more taste. The branding for the app can be found in appendix E2.

The application was named Savr as the focus of the app is to save food and the name plays on the word saver like someone who saves food. The name is short and easy to remember. The slogan 'less waste, more taste' was created as a way for the users to connect food waste with enjoying a homemade meal.

Figure 14. Savr logo

The inclusion of a leaf in the logo (Figure 14) refers to the sustainability aspect of the app. The leaf has two colors going from green to yellow, symbolizing freshness and food nearing expiration. The logo consists of simple rounded shapes.

The tone of voice is represented by the following characteristics: encouraging, helpful, and fun. A friendly and supportive tone makes trying to reduce food waste more fun. It turns it into a game with a friend who is trying to help you.

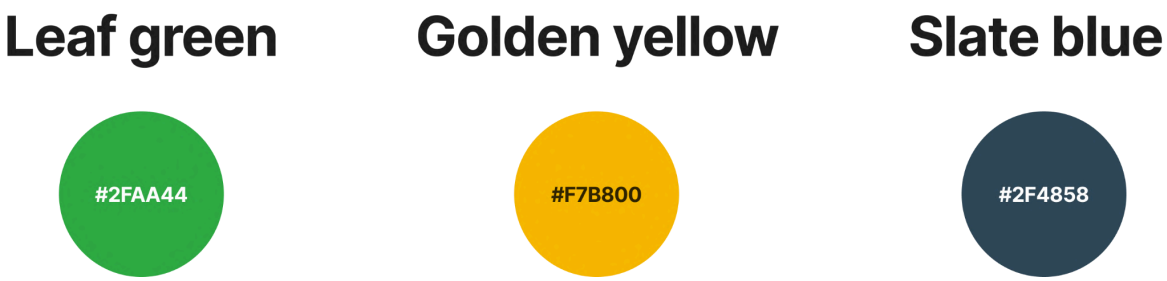

Figure 15. Savr brand colors

Regarding the brand colors (Figure 15), the following three main colors were selected: leaf green, golden yellow, and slate blue. Green was chosen as it represents freshness and eco values. Yellow adds energy and is associated with appetite stimulation. It also keeps the interface lively. The dark grayish blue was chosen as it is used in other modern apps helping reinforce the idea of a contemporary app and it makes for good contrast which helps with accessibility.

Typography wise Inter was chosen as the primary font. Inter is easily readable. It works well for buttons and text body. Nunito was chosen to be used as a display font. Nunito is rounded which makes it friendly. It works well as a display font in titles to give a unique character to the app and it can also be used as well for body text.

Savr's brand iconography is characterized as minimal and functional. The app takes inspiration from Too Good To Go and MyNetDiary which both use line-based icons. These icons are simple and clear which makes them easy to recognize. Unnecessary details are avoided as complex icons slow users down so a clean, minimal approach may help with accessibility. The app only uses food imagery, while users can share photos without any content restrictions.

4.4.3 Paper prototype

Concepts for the screens were sketched, allowing for quick production of ideas and exploration of concepts. These were refined and a paper prototype was created, which provided the opportunity to test some early-stage concepts with the users. Paper prototyping is a rapid and inexpensive way to design, test, and refine user interfaces [33].

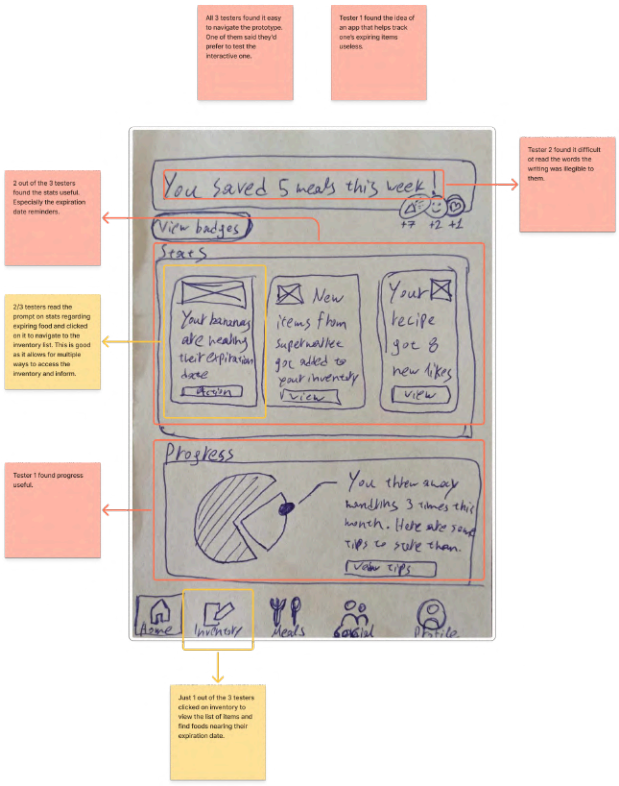

Figure 16. Paper prototype with user feedback

An in-person informal guerrilla test was conducted on three participants. Testing with these three participants provided useful feedback (Figure 16). The results of the paper prototypes can be found in appendix E3.

3.4.4 Digital prototypes

Based on the feedback from the paper prototype testing, two interactive digital prototypes (Figure 17) were created in Figma. This was used to refine the user flow of the two versions of the application, and then tested informally with two participants, one online and one in person. The aim was to ensure the translation from paper to digital was comparable and that no major usability errors occurred [34]. The two digital prototypes can be found in appendix E4.

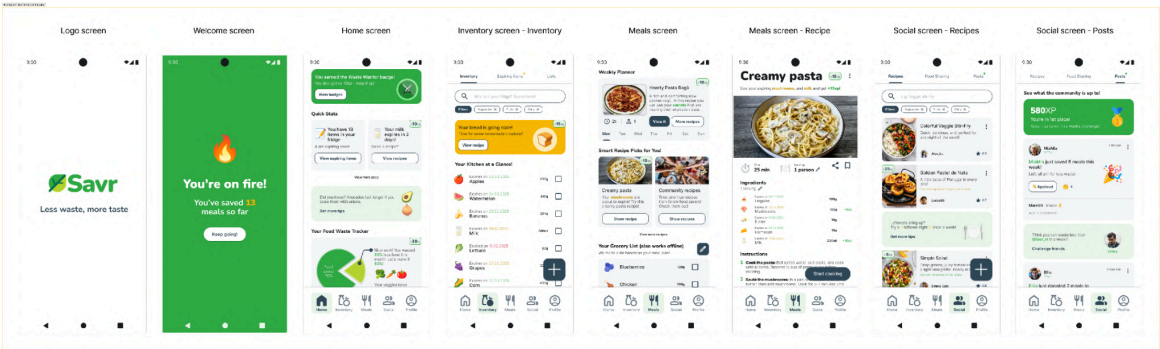

Figure 17. Some screens from prototype A

4.5 **Test stage findings**

4.5.1 **Pre and post-test surveys**

Pre-test IMI, post-test IMI, and post-test SUS surveys were created for each testing group. Different surveys were made to collect data during the A/B testing.

The IMI surveys are based on the Intrinsic Motivation Inventory (IMI) and use the 22 questions created for task evaluation. The questionnaire contains seven questions from the interest/ enjoyment subscale, five questions from the perceived competence subscale, five questions from the perceived choice subscale, and five questions from the pressure/ tension subscale. Participants were asked to indicate how true each statement was for them choosing a number on a scale from 1 = strongly disagree to 7 = strongly agree. The pre-test IMI surveys aimed to collect data on users' motivation regarding their experience with cooking on their own. The post-test IMI surveys aimed to collect data on users' motivation regarding their experience of cooking more sustainably with the use of the app they just interacted with. Both pre and post-test IMI surveys can be found in appendix F2 and appendix F3 respectively.

The post-test SUS survey is based on the System Usability Scale (SUS). The SUS is a 10-item questionnaire with five response options. It provides a global measure of system satisfaction and sub-scales of usability and learnability. Participants were asked to indicate how true each statement was for them choosing a number on a scale from 1 = strongly disagree to 5 = strongly agree. The post-test SUS survey can be found in appendix F4.

4.5.2 **Post-test user interviews**

After interaction with either Prototype A or Prototype B, all participants were asked to take part in a post-test interview. The interview consisted of eleven questions. The post-test interviews aimed to collect qualitative data from the users. Thematic analysis was then performed. The post-test user interview questions can be found in appendix F5.

4.5.3 **User testing tasks**

During user testing, all participants in both groups were asked to complete four tasks. These were designed to make the users interact with the prototypes and stimulate an environment for the users to perform actions as

if they were using the app. All four tasks were simple enough for the users to complete and were kept the same for both testing groups. The user testing tasks can be found in appendix F6.

4.5.4 **Pilot testing**

Two moderated pilot tests were conducted to assess the final design iteration and user test. One pilot test was held online while the other one was in person. The pilot tests provided valuable feedback. Through the pilot testing, it became apparent that both tasks and introduction needed to be amended. Pilot tester one needed more information on what the app does and what their role is. After amending the tasks and introduction it became evident from pilot tester two that giving more detailed tasks helped the tester not get confused. The vagueness of task one did not help tester one but the explanation and the introduction proved useful for tester two. Inspiration to change the tasks and give more context came from the personas. The results from the pilot test can be found in appendix F7.

4.5.5 **User testing**

The findings from user research were used in the ideation and creation of two applications. A user-led approach was taken that involved iterative design and testing from low-fidelity to high-fidelity prototypes. The resulting prototypes were then assessed in a between-groups user test, the aim of which was to compare the association between independent variables with two different groups, Group A which interacted with Prototype A with gamification and nudging elements, and Group B which interacted with Prortype B with no gamification and nudging elements (Figure 18). Both prototypes can be found in appendix A.

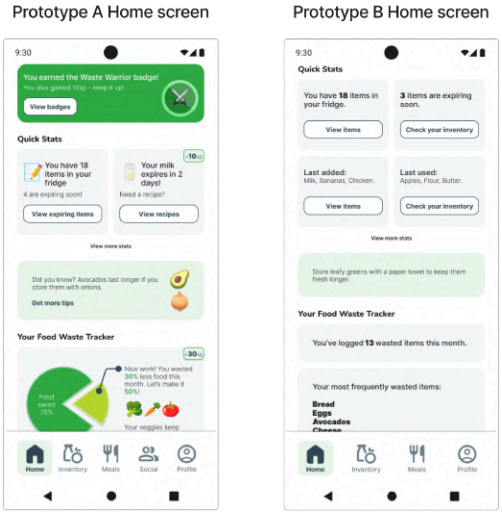

Figure 18. Contrast between the home screens of the two versions

In total 30 participants took part in the user testing. Five user tests were performed in person while the other 25 were held online via Microsoft Teams. Each participant was randomly allocated to either Group A or Group B. Before initiating the test, all participants were given an introduction to the project and what to expect in this user testing. They were made aware they were not forced to participate and that they could end the user testing whenever they needed to. They were informed that they would remain anonymous and that all information collected would not be able to be traced back to them and that only the host of the user testing

would have access to their information. For reference, they were assigned a participant number and provided with the e-mail address of the host in case they wanted to contact someone in the future regarding questions about the project or if they wanted to withdraw their participation and have their data deleted. All participants were informed that all of their collected data would be deleted once the project was completed. After consenting, the participants were then provided with the pre-test IMI survey and asked to fill it out. After completing the pre-test IMI survey they were asked to interact with the app and were asked to complete four tasks. After completing the tasks they were asked to fill out the post-test IMI survey and after that, they were asked to fill out the post-test SUS survey.

Figure 19. Interesting responses from the user interviews

Lastly, the participants were asked to answer eleven post-test interview questions (Figure 19). After answering the questions they were informed that they had reached the end of the user testing and were thanked for taking part in it. The answers to the user testing tasks for Group A and Group B can be found in appendix F9. The answers to the post-test interview questions for Group A and Group B can be found in appendix F10.

4.5.6 **Survey responses**

The surveys were developed using Microsoft Forms. The data was collected through Microsoft Forms. Average ratings for all questions were collected for every survey. All survey question means can be found in appendix F8.

4.5.7 Post-interview responses

All thirty participants took part in the post-test interview. The post-test interview was held to help collect qualitative data from the participants. All answers to the post-interview questions can be found in appendix F10.

4.6 Implement stage findings

4.6.1 Next steps

Taking into account the feedback received from the user testing the following changes are to be implemented in order to improve the user's experience of the product. Storage tips need to move to Inventory instead of Profile (Figure 20).

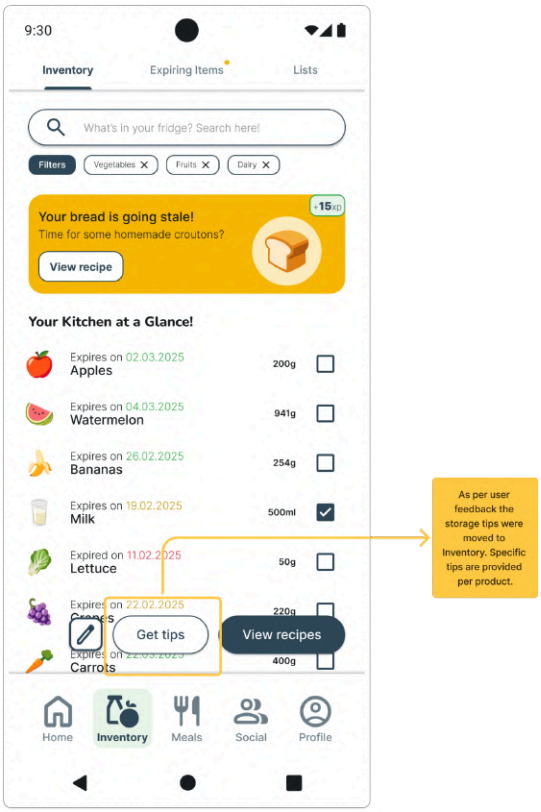

Figure 20. Implementation of user feedback

Recipe filtering and the ability to search for specific recipes not just what is recommended need to be included in the design. Gamification needs to be optional. Some users loved it but others did not so giving the option to opt out would benefit the product. the frequency at which popups show needs to be reduced. The Home

Screen has too much information which overwhelms some users. The layout of the Home Screen needs to be improved. There needs to be a clear hierarchy of what content must be prioritized. Lastly, there must be implemented a way for the users to control the frequency of the reminders they get.

5. RESULTS

This chapter will examine the results of the final experiment performed for this study.

5.1 Quantitative results

5.1.1 IMI and SUS scores

IMI and SUS scores were calculated for every survey. For the IMI survey, an average score for each subscale was calculated by summing up all the average scores of all questions related to the subscale and dividing by the total number of the questions related to it. To score the IMI, first, all questions marked with R need to be reverse scored. That is done by subtracting the item response from eight and then using the resulting number as the item score. And then each subscale scores are calculated by averaging across all of the items on that subscale. The subscale scores are then used in the analyses of relevant questions. All scores for all surveys can be found in appendix F11.

For Group A the IMI survey mean/ average scores for each subscale were calculated to be the following.
Group A pre-test IMI scores:
Interest/Enjoyment: 5.10
Perceived competence: 4.66
Perceived choice: 4.25
Pressure/Tension: 2.99

Group A post-test IMI scores:
Interest/Enjoyment: 5.68
Perceived competence: 5.36
Perceived choice: 5.36
Pressure/Tension: 2.18

For Group B the IMI survey mean/ average scores for each subscale were calculated to be the following.
Group B pre-test IMI scores:
Interest/Enjoyment: 4.79
Perceived competence: 4.30
Perceived choice: 4.41
Pressure/Tension: 3.30

Group B post-test IMI scores:
Interest/Enjoyment: 5.61
Perceived competence: 5.34
Perceived choice: 5.45
Pressure/Tension: 2.33

For the IMI survey, an average score for each question was calculated. To calculate the SUS score, for odd-numbered questions (1, 3, 5, 7, 9), one is subtracted from the user's score. For even-numbered questions (2, 4, 6, 8, 10), the user's score is subtracted from 5. Then the sum is multiplied by 2.5 to get the final SUS score. The SUS score can range from 0 to 100, with a higher score indicating better usability. A score of 85 and above indicates excellent usability,a score of 70–84 indicates good usability, a score of50–69 indicates okay usability, and a scorebelow 50 indicates poor usability. For Group A the SUS score was calculated to be 82.2 which indicates good usability. For Group B the SUS score was calculated to be 86.1 which indicates excellent usability. All scores for the Group A and Group B SUS survey can be found in appendix F8, and F11.

5.1.2 **Within-group changes**

Changes in percentage for Group A (Figure 21) from pre-test to post-test IMI scores for each subscale were calculated and are as follows:
Interest/Enjoyment: 11.37% increase
Perceived competence: 15.02% increase
Perceived choice: 26.12% increase
Pressure/Tension: -27.09% decrease

Changes in percentage for Group B (Figure 21) from pre-test to post-test IMI scores for each subscale were calculated and are as follows:
Interest/Enjoyment: 17.12% increase
Perceived competence: 24.19% increase
Perceived choice: 23.58% increase
Pressure/Tension: -29.39% decrease

Within-group changes

Subscale	Group A	Group B
Interest/Enjoyment	11.37%	17.12%
Perceived competence	15.02%	24.19%
Perceived choice	26.12%	23.58%
Pressure/Tension	-27.09%	-29.39%

Figure 21. Table with the within-group changes

Paired samples t-tests were performed to test statistical significance between pre and post-test scores for every subscale in both groups. The p-value was calculated for each subscale where if $p > 0.05$ then there is statistical insignificance, whereas $p \leq 0.05$ indicates statistical significance. This was calculated by incorporating the raw data from the IMI surveys into Gemini and using the scipy.stats.ttest_rel function from scipy.stats library in Python. The t-tests can be found in appendix F13, and the result can be found in appendix F14.

For Group A the p-value for each subscale is the following:
Interest/Enjoyment: p = 0.022 (significant)
Perceived competence: p = 0.002 (significant)
Perceived choice: p = 0.004 (significant)
Pressure/Tension: p = 0.008 (significant)

There was a statistically significant increase from the pre-test to the post-test in Interest/Enjoyment (p=0.022), Perceived Competence (p=0.002), and Perceived Choice (p=0.004). There was also a statistically significant decrease in Pressure/Tension (p=0.008). This suggests using the app in Group A significantly improved all aspects of intrinsic motivation measured.

For Group B the p-value for each subscale is the following:
Interest/Enjoyment: p = 0.027 (significant)
Perceived competence: p = 0.018 (significant)
Perceived choice: p = 0.012 (significant)
Pressure/Tension: p = 0.030 (significant)

There was a statistically significant increase from the pre-test to the post-test in Interest/Enjoyment (p=0.027), Perceived Competence (p=0.018), and Perceived Choice (p=0.012). There was also a statistically significant decrease in Pressure/Tension (p=0.030). This suggests using the app in Group B also significantly improved all aspects of intrinsic motivation measured.

5.1.3 Between groups changes

Changes in percentage from post-test interaction from Prototype B (non-gamified, no nudging) to Prototype A (gamification, nudges) for each subscale were calculated and are as follows:
Interest/Enjoyment: 1.23% increase
Perceived competence: 0.37% increase
Perceived choice: -1.68% decrease
Pressure/Tension: -6.88% decrease

Independent samples t-tests were performed to test the statistical significance between post-test scores for every subscale between Group A and Group B.

The p-value for each subscale for post-test comparison between the two groups is the following:
Interest/Enjoyment: p = 0.575 (not significant)
Perceived competence: p = 0.476 (not significant)
Perceived choice: p = 0.894 (not significant)

Pressure/Tension: p = 0.728 (not significant)

Both prototypes significantly improved intrinsic motivation from the pre-test to the post-test. However, there were no statistically significant differences in the amount of change between Prototype A (gamified) and Prototype B (non-gamified) on any IMI subscale (all $p > 0.05$).

5.1.4 Hypothesis 1 (H1)

This study hypothesized that integrating gamified elements in Prototype A will increase user motivation to take up sustainable cooking and lead to a more effective food waste reduction compared to Prototype B which has no such features. An independent samples t-test was conducted, where it was discovered that there were no significant differences in score changes between Group A and Group B. Therefore, the null hypothesis is retained, “There is no difference in the levels of users’ motivation to take up sustainable cooking between the two versions of the app.”

5.1.5 Hypothesis 2 (H2)

The second hypothesis proposed that reminders and recipe suggestions in Prototype A will improve the motivation of users to engage with a cooking app more than in the case of Prototype B which has no digital nudges. Through the independent samples t-test it was discovered that there were no significant differences in score changes between Group A and Group B. Therefore, the null hypothesis is retained, “There is no difference in the levels of users’ motivation to engage with either version of the app.”

5.2 Qualitative results

5.2.1 User testing thematic analysis

Thematic analysis was used on the post-interview data to identify patterns [25]. The data was analyzed in four groups, usability, features, motivation, and pain point. The user-testing thematic analysis can be found in appendix F15.

Regarding what worked well usability-wise, it was noted that almost all users in both groups found the app easy to use (Figure 22). A lot of them said that the interface was clean. The expiration date list was easy to locate for nearly all users in both groups. Recipe suggestions based on ingredients the users already have were appreciated by almost all the users. Things that didn’t work well were also noted. Finding the list with all the tips was the most noted issue in both groups. Almost all of the users did not expect tips to be in the Profile tab. They looked for them in Inventory or Home first. The Meals tab was unclear to some users. They expected to find ingredients or filtering by ingredients recipes in there.

Figure 22. Interesting responses from the user interviews

Regarding features that worked well, users liked knowing which foods were about to go bad. Expiration date tracking was viewed as the main selling point of the app. Recipe suggestions based on available ingredients were the most praised feature. Inventory management was also well received. However, there were features that didn't do that well. Some users of group A liked the experience points but they were mostly ignored by most. The social aspect in the Community tab was not mentioned as a key feature. Users didn't have the opportunity to interact with it a lot, but those who did said they felt indifferent to its existence. Most users did not directly interact with Meal planning during the testing but those who did expected to have more control. They want to choose from recipes on their own.

Regarding motivation, participants in group A found expiration reminders beneficial to their experience using the app. Participants in group B also appreciated the expiration dates on the food items. Group A users didn't mind earning experience points (XP) but at the same time most said that earning XP wasn't the main motivator of using the app. Just receiving expiration reminders and thus being able to save food was enough of a motivator for them. Group B users found expiration date tracking and recipe suggestions useful and motivational enough to us the app, even without gamification. However, many users of group A didn't care about XP points. They found them unnecessary. Some users from group B said they would benefit from reminders (nudges) but not on a daily basis. Gamification wasn't equally effective for all users. Some enjoyed the gamelike feeling the app gave them, while others didn't see the point.

As for pain points, in group A, some users complained about the popups (nudging). Two of them expressed feelings of frustration to the point that they were considering closing the app. Some felt indifferent to the inclusion of gamification in the app. XP collection felt unnecessary. Some users said that the Home screen felt cluttered. There was too much information. In group B there was a lack of reminders and it was noted that some users said they would engage more with the app if it provided reminders regarding expiring food.

6. DISCUSSION

This section will discuss the results of the between-groups user test and qualitative analysis, and how the findings may inform the design of food-managing gamified systems.

The study offers insight into the effects of the app to motivate users to cook more sustainably. Both versions of the app showed a statistically significant positive impact on the user's intrinsic motivation. However, there were no significant statistical differences in motivation levels between the two versions. This suggests that the inclusion of gamified elements and digital nudges in a food management app does not provide significant advantages. Hence both hypotheses 1 (H1) and 2 (H2) could not be supported. However, based on qualitative data, users seem to overwhelmingly favor the inclusion of digital nudges in the form of reminders and recipe suggestions. This needs to be further examined and tested to verify if H2 could be supported. A bigger testing group is required.

Through the qualitative data, it became apparent that gamification is not universally perceived as positive in the setting of a food-managing app like that of Savr. Many users found it unnecessary. Implementing gamification in such an app should be carefully considered and if implemented there must be a way for the users to opt out if they want.

Most users stated that they felt motivated to use the app event without the gamification. The possibility of having a positive impact on the environment by reducing one’s food waste and saving money was enough of a motivator for them to use the app. Participants from group A responded positively to the nudging features. This suggested that features such as expiration date reminders and recipe suggestions based on available ingredients nearing their expiration date are the biggest motivators. The increase in perceived competence might come from the fact that users feel better equipped to manage their food inventory and not by gamification. This is also supported by the fact that Prototype B got a slightly higher SUS score.

The usability test found some usability issues. Users found it hard to locate all the storage tips and some felt uncertain regarding the functionality of the Meals tab. This means that the information architecture of the app needs refinement. Users also noted the need for more control in regard to the frequency of notifications received and also how many or if any at all pop-ups they get.

In conclusion, the study shows that there is potential for a food management app to enhance users’ motivation to cook more sustainably. However, the inclusion of gamification does not positively impact the motivation of the users of such an app. Digital nudging seems to have a positive impact on the users but further study is required to verify it. The core value of inventory management, recipe suggestions, and expiration tracking of food inventory appears to be a strong foundation for such an app.

7. CONCLUSIONS & FUTURE WORK

7.1 Summary

This research examined the impact of gamification and digital nudging on the motivation of users of a smart food management app to reduce their food waste by cooking more sustainably. Two versions of an app were designed. Prototype A had gamified elements and digital nudging, while Prototype B was void of such features. Both versions were A/B tested with two different groups. The study employed a mixed-methods approach. Pre and post-test Intrinsic Motivation Inventory (IMI) and System Usability Scale (SUS) surveys were used to collect quantitative data. To collect qualitative data, post-test interviews were hosted. The results indicate that both prototypes had a positive impact on the motivation of users. However, there was no statistical significance in the difference in the levels of motivation improvement between the two versions.

7.2 Key contributions

This study contributes to the research of using technology to handle food waste. It gives insight into users' preferences. The research shows how important features such as inventory tracking, expiration reminders, and recipe suggestions based on available ingredients nearing their expiration date are to a food management app. The findings suggest that gamification does not have a positive impact on the motivation of the users of such apps. Digital nudging was shown to be perceived universally as positive by all participants but further investigation is needed to determine actual improvement in levels of motivation.

7.3 Limitations

The main limitation of the study is the sample size. Thirty participants were recruited in total. This might limit the generalizability of the findings to a broader population. Participants were recruited through personal networks, the university, and through social media. This might have introduced some bias when it comes to selecting favorable participants. It is acknowledged that the gamified and nudging features might not be the most effective, and there are other variations that might work better in such cases.

7.4 Future research

For future research, further research could be performed on solely digital nudging. This way the impact of digital nudges on the motivation levels of users to cook more sustainably could be studied with more detail. A bigger sample size is needed. A larger and more diverse sample size would enhance the generalizability of the findings. There could be further research on the aspect of personalization of the app to the users' liking which could increase motivation levels. Also, longitudinal studies could be performed to measure the long-term impact of such an application. The study could focus more on the amount of food waste that is reduced. Studying ways to integrate the app with other household appliances could be promising. This could allow for a more optimized automated food inventory creation and updating.

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APPENDICES

This is the appendix section. It contains links to the results of the user research that was carried out, the design artefacts produced as part of the design process, a video presentation summarising the study, and a showreel of the design artefact produced.

Appendix A: Prototypes

A1: Prototype A
A2: Prototype B

Appendix B: Empathize

B1: Initial ideas
B2: Survey - Empathize with users
B3: Survey - Empathize with users - Results and insights
B4: Quantitative analysis
B5: Interview - Empathize with users
B6: Interview - Empathize with users - Results and insights
B7: Thematic analysis

Appendix C: Define

C1: Persona 1 - Sarah Greene
C2: Persona 2 - Daniel Perez
C3: Empathy map 1 - Sarah Greene
C4: Empathy map 2 - Daniel Perez
C5: User journey map 1 - Sarah Greene
C6: User journey map 2 - Daniel Perez

Appendix D: Ideate

D1: Competitor analysis
D2: Competitor visual analysis board
D3: App site map

Appendix E: Prototype

E1: Mood board
E2: Branding
E3: Paper prototype
E4: Interactive prototypes

Appendix F: Test

F1: Introduction to the experiment
F2: Pre-test IMI survey
F3: Post-test IMI survey
F4: Post-test SUS survey
F5: Post-test user interview questions
F6: User testing tasks
F7: Pilot test
F8: Survey responses
F9: User testing tasks responses
F10: Post-test interview questions responses
F11: IMI and SUS scores
F12: Standard deviations
F13: T-testing