



Final Year Project

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Abstract

This project presents the research design, development, and evaluation of *Imperfectly Fresh*, a native iOS mobile application aimed at reducing food waste among university students through food tracking, peer sharing, and gamified behavior change. Grounded in sustainability goals and guided by the Theory of Planned Behavior, the app addresses both logistical and psychological barriers to responsible food consumption. Students frequently discard edible food due to poor planning, limited awareness, and lack of motivation challenges this app seeks to overcome through intuitive design, timely notifications, and community driven food exchange groups. A tier-based rewards system encourages continued engagement and sustainable habits, using visual feedback and positive reinforcement. The project evaluates existing food tracking applications, identifies critical gaps, and incorporates these insights into a user-centered, behaviorally informed solution. Usability testing with university students demonstrated high engagement and validated the app's potential to promote daily sustainable practices. *Imperfectly Fresh* offers a practical, scalable approach to tackling food waste at the individual level, with broader implications for environmental consciousness and digital sustainability interventions.

Declaration of Originality

In signing this declaration, you are conforming, in writing, that the submitted work is entirely your own original work, except where clearly attributed otherwise, and that it has not been submitted partly or wholly for any other educational award.

I hereby declare that:

- *this is all my own work, unless clearly indicated otherwise, with full and proper accreditation;*
- *with respect to my own work: none of it has been submitted at any educational institution contributing in any way to an educational award;*
- *with respect to another's work: all text, diagrams, code, or ideas, whether verbatim, paraphrased or otherwise modified or adapted, have been duly attributed to the source in a scholarly manner, whether from books, papers, lecture notes or any other student's work, whether published or unpublished, electronically or in print.*



Signed: Date: 17/04/2025

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I would like to express my heartfelt gratitude to my supervisor, Laura, for her invaluable support, guidance, and encouragement throughout the development of this project and my final year of college. Her expertise and advice have been instrumental in shaping the direction of this work.

I am deeply thankful to my friends and family for their unwavering support and motivation during this journey. Their encouragement helped me stay focused and positive throughout the entire process.

Introduction

“What features could be implemented in a food expiration tracking app that can promote food sharing amongst third level students, and how can these be implemented to encourage awareness in food waste?”

Framing the Problem

Food waste is a critical global concern, with over 1.3 billion tons of edible food lost annually. This waste significantly contributes to climate change through methane emissions and exacerbates food security, even as millions face hunger worldwide. In fact, *“if food waste was a country, it would be the third-largest emitter of greenhouse gases behind the United States and China”* (FAO, 2013).

A substantial amount of this waste originates from households and student accommodations, where lack of planning, improper storage, and overbuying are common (Quested et al.). Households are the largest contributors to this problem, accounting for over 50% of global food waste (Schneider, 2008). Within this category, students represent a specific demographic that faces unique challenges when it comes to managing food effectively. Factors such as limited budgets, shared accommodations, poor meal planning, and a lack of awareness often lead to the premature disposal of edible food (Van Alboom, 2021).

This project responds to the problem of food waste by providing students with an initiative tool that not only monitors expiration dates but also encourages them to share excess food within their local communities. The primary aim is to support sustainable behaviour change through an engaging interface and a gamified rewards system that motivates users to use for share food before it expires. The apps development is guided by the research question “What features could be implemented in a food expiration tracking app that can promote food sharing amongst third level students, and how can these be implemented to encourage awareness in food waste?” This project is highly relevant in today’s context, where promoting food sustainability and minimizing waste is more important than ever especially among young adults who are still forming lifelong consumption habits.

The aim is to evaluate how digital interventions particularly those involving behavioural nudges, peer collaboration, gamification and how it can promote sustainable consumption patterns among students.

Background information

Beyond its environmental impact, food waste also has serious economic and social consequences. While millions of tons of edible food are discarded annually, 783 million people globally faced hunger in 2022 (FAO,2022). This shocking disparity underscores the inefficiency of current food systems and highlights the urgent need for change, not only in food production and distribution but also in consumption behaviors at the individual level.

Students face specific challenges including irregular eating schedules, lack of food planning skills, and limited storage space. Often, they forget what is in their fridge or over-purchase due to lack of coordination with housemates. Importantly, the issue is not just purely logistical, it is also behavioral. As identified in psychological frameworks like the **Theory of Planned Behavior (TPB)** individuals' actions are influenced by their intentions, which are shaped by attitudes, subjective norms, and perceived behavioral control. In the context of food waste, students may be aware that waste is undesirable, but without the tools, reminders, or social motivation to act differently, intentions often fail to turn into action (La Barbera et al., 2022).

This is where a targeted mobile application can make a measurable impactful difference by supporting decision-making, reminding users, and incorporating positive reinforcement mechanisms for sustainable actions particularly among university students who are still forming lifelong consumption habits.

Research Question

This research question explores both the technical and social dimensions of the application. It aims to understand whether mobile technologies can drive meaningful behavior change when it comes to managing food resources and whether features such as social interaction and gamification enhance effectiveness.

Furthermore, it positions the project within the broader context of technology-driven sustainability, examining how mobile technologies can be designed to address environmental challenges through human-centered design.

Problem Statement

While there are various food management apps that exist on the market, during my app analysis most of the apps focused on logistics, such as creating shopping lists, but few incorporate behavioral motivation or peer interaction as part of their design, which research shows are vital for sustained engagement (Grimes & Harper, 2008; Ganglbauer et al., 2014).

Furthermore, food sharing as a concept has not been widely integrated into mobile applications targeting waste reduction, despite its potential for social and environmental impact. The absence of real-time, localized, and user-friendly platforms for redistributing excess food among students means that many items that could be consumed by others are instead discarded.

Therefore, there is a clear need for a mobile application that not only supports students in tracking expiration dates but also enables them to **share food, earn rewards**, and feel more connected to a community that values sustainability. The challenge lies in designing an interface that is easy to use, visually appealing, and psychologically motivating, while also being technically robust for everyday student use.

Aim and Objectives of the Project

The primary aim of this project is to develop a mobile application that helps students reduce food waste through an effective combination of food tracking, timely notifications, and

community-based sharing. The app is designed to function both as a practical tool and a behavioral intervention, influencing others to adopt more sustainable food habits. The app will:

- Enable easy tracking of food expiration dates
- Support sharing of excess
- Use gamification (badges, tiers, visual feedback) to reinforce sustainable behavior
- Engagement to normalize food sharing

Importance and Relevance

Students represent future professionals, leaders, consumers, and decision-makers. If sustainable food behaviors can be cultivated during their university years, these habits are likely to extend into adulthood, multiplying the long-term impact on consumption patterns (Aydin & Aydin, 2022). Moreover, as students often live in shared housing, there is an opportunity to normalize food sharing, reduce duplication of food purchases, and foster a sense of community responsibility.

The project is also highly relevant in the age of modern mobile technology, the relevance of app-based interventions has never been greater by leveraging native iOS features such as notifications, real-time scanning, cloud synchronization, and a social interaction allows *“Imperfectly Fresh”* to become more than just a digital tool, it becomes a daily companion that supports responsible decision-making and builds awareness and contributes to a more sustainable future.

From a software development standpoint, this project illustrates how thoughtful design at the intersection of technology, behavior science and sustainability can result in a digital product that is not only functional but also socially and environmentally impactful.

Literature Review

Chapter 2: Literature Review: Food Waste Among Students & Mobile App Interventions

This Chapter explores the existing research related to food waste in student populations and the use of digital interventions to address this issue particularly with mobile applications. The aim is to contextualize the development of *Imperfectly Fresh* and to inform its design through existing scholarship and app analysis. The review is structured into four main sections:

- **Section 1** examines the scope and behavioral causes of food waste among university students, establishing the need for targeted interventions.
- **Section 2** explores behavioral change theories, particularly the Theory of Planned Behavior (TPB), to frame how intention and action intersect.
- **Section 3** evaluates current digital food waste solutions, highlighting what features have been successful and where they fall short.
- **Section 4** presents a comparative app analysis and identifies key design requirements for *Imperfectly Fresh* based on gaps in the market.

Together, these sections serve to justify the research question and inform user-centered, behaviorally motivated features that the app incorporates.

2.1 Food Waste Issues Among Students

Plate waste, referring to uneaten food left on plates, accounts for approximately 86.7% of all food waste generated in university settings (Van Alboom, 2021). This figure indicates how student behavior is a major contributing factor to overall food waste on campus. Food waste is increasingly prevalent among the younger generation, highlighting the urgent need for targeted behavioral interventions at the university level as students often overbuy or duplicate groceries within shared accommodations, leading to spoilage and unnecessary waste (La Barbera et al., 2022).

1. Defining Food Waste

According to the Food and Agriculture Organization (FAO, 2022) they define food waste (FW) as any intended for human consumption that is discarded, either due to spoilage or reaching its expiry date. Similarly, Van Alboom (2021) describes it as edible food meant for human use that is ultimately not utilized for any reason. These definitions emphasize that food being discarded is still suitable for consumption and that waste is often avoidable.

2.2 Behavioral Theories: Theory of Planned Behavior (TPB)

The Theory of Planned Behavior (TPB) is a widely used psychological framework that predicts an individual's intention to act in a specific way at a given time and place (Werf et al., 2019;

La Barbera et al., 2022). (Ajzen, 1991) provides a useful structure, asserting that behavior is predicted by:

- Attitudes towards the behavior
- Subjective norms (social pressure or influence)
- Perceived behavioral control (belief in one's ability to carry out the behavior)

This model is particularly relevant for understanding and improving food waste behaviours among students. Subjective norms are noted as especially influential in promoting engagement and sustainable actions among students. This theory is highly relevant to “*Imperfectly Fresh*,” which encourages behavioural change through social interaction, peer motivation and positive reinforcement.

2. Digital Interventions & UX Platforms

Behavioral change interventions supported by User Experience Platforms (UXPs) have shown significant potential in reducing food waste (Evans et al., 2015). Applications that track food expiry dates, provide smart reminders, and promote sustainable habits can effectively support behavioral change. Features such as awareness notifications and predictive analytics (e.g., smart forecasting) help users make better decisions regarding food consumption and purchasing.

2.Mobile Applications as Behavior Change Tools

The study *Food Talks Back: Exploring the Role of Mobile Applications in Reducing Domestic Food Wastage* highlights how mobile technologies can drive meaningful reductions in food waste. Three key applications were examined:

- Fridge Pal: Assists with household food management, tracking supply and expiry dates
- LeftoverSwap: Facilitates anonymous food sharing
- EatChaFood- Combines food tracking with social interaction and sharing

Studies show these apps help increase food literacy, but often users disengage over time due to lack of motivation or reward (Yu et al., 2023). In a separate review, Ganglbauer et al. (2014) explored the FoodSharing.de community platform, which showed how social food sharing-sharing networks can increase commitment to sustainability.

These findings support *Imperfectly Fresh*'s hybrid model that combines food tracking, social sharing, and gamified progression.

3. Impact of Food Waste on Sustainability

Food waste poses a significant environmental and sustainability threat. According to Schneider (2008), 25% of the global edible food supply is wasted each year. Further studies argue that the majority of food waste occurs within households (Ambler-Ewards et al., 2009), making it crucial to intervene at the domestic level. Despite numerous public and private efforts, food waste continues to account for 40-60% of household's garbage and approximately 20% of landfill contents in developed nations (Caswell, 2008; Wade, 2011). Notably, two-thirds of this

waste is preventable (Schneider & Obersteiner, 2007), reinforcing the need for individual-level interventions like *“Imperfectly Fresh”*.

4. Community-Focused Digital Solutions

Community-based platforms also demonstrate promise in reducing food waste. For example, Ganglbauer et al. (2014) explored the use of FoodSharing.de, an online platform facilitating food exchange among individuals, farmers, organizations, and retailers in Germany and Austria. The platform successfully created a food-sharing community of 17,000 active users, evidencing the power of digital platforms to encourage collective action. Likewise, Grimes & Harper (2008) and Wei & Nakatsu (2012) found that the use of mobile and online technologies can encourage social interaction and peer food sharing, both key features reflected in the design of *“Imperfectly Fresh”*

Technological Innovations in Food Management

Rouillard (2012) investigated how embedding mobile devices into food storage environments could reduce food waste. His study demonstrated that interactive tech features like barcode scanning, voice input, image recognition, and expiry tracking can effectively support food consumption habits. These interventions leverage Human-Computer Interaction (HCI) to assist users in food management and waste reduction.

These technological tools are increasingly integrated into mobile applications like *“Imperfectly Fresh,”* particularly through VisionKit for OCR-based expiry scanning.

5. Gamification

Gamification refers to the application of game-design elements and principles in non-game contexts to enhance user engagement, motivation, and behaviour change. These elements may include point scoring, tiered progression, rewards, leaderboards, and visual indicators of progress. In the context of digital sustainability tools like *“Imperfectly Fresh,”* gamification transforms routine behaviours into interactive experiences that encourage repeated use and foster a sense of accomplishment. The use of visual icons, progress points, and positive reinforcement aligns with psychological theories such as operant conditioning reinforcing sustainable behaviour through rewarding experiences.

6. Conclusion

The literature clearly demonstrates that student food waste is a significant, yet preventable issue. Behavioral theories like TPB offer insights into how attitudes, social norms, and perceived control influence wasteful habits. mobile applications, gamification, social food sharing, and real-time notifications offer a promising pathway for sustainable improvement and shows strong potential for behavioral interventions.

However, the literature also shows that current applications may not fully engage users long-term, as existing apps often lack a comprehensive approach. This signals the need for more dynamic, user-focused platforms that combine multiple functions tracking, gamification, social

interaction, and forecasting to address the ongoing problem of food waste more effectively on campuses and in households.

2. Apple Store and Google Play Analysis: Gaps and Opportunities in Existing Digital Tools

To further contextualize the design of *Imperfectly Fresh*, this section evaluates the current landscape of food expiration tracking apps which are available on both major mobile platforms. This analysis explores the core features, design approaches, and user engagement strategies of these applications, with specific attention to how these apps support behavioral change through notifications, reminders, inventory tracking, gamification, and user interface design.

By examining popular apps such as “**Food Expiration Tracker Pro**”, “**BEEP- Expiry Date Tracking**”, “**Pantry inventory, track food**”, “**FridgeGuide Ai**”, “**Food Organizer-Pantry Kit**”, “**Freshly, Floxx: Scan**”, “**Save & Simplify**”, and on the Google play store, “**Freeco - Food Expiry Date Reminder & Food QR Scanner app**”, this review identifies strengths, weaknesses, and gaps in current solutions. The objective of this review is to gain acknowledgement on how effective these tools address food waste at the household level and what lessons can be applied to the development of new or improved digital interventions, especially those targeting student populations and sustainable lifestyles. The review is based on five key criteria: core features, user interface (UI), reviews, and limitations

Summary of App Findings

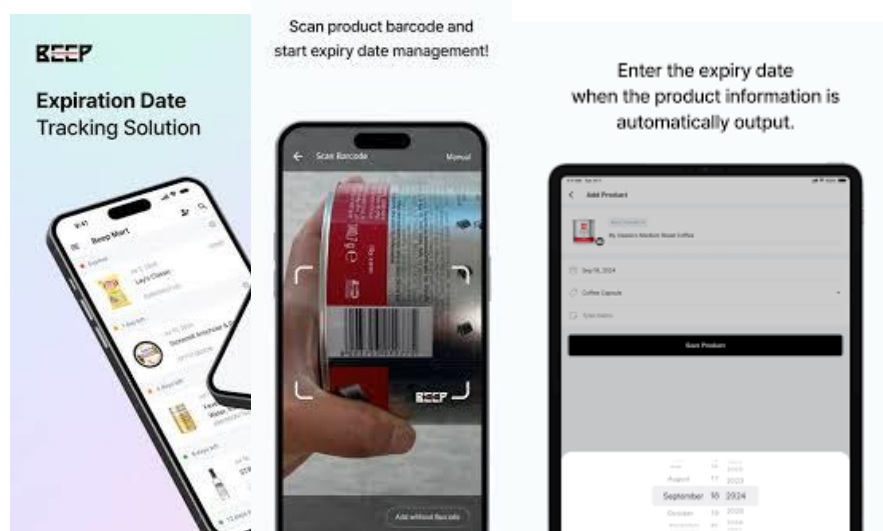
BEEP- Expiry Date Tracking

“BEEP” allows users to scan barcodes and receive alerts about expiring food items, paired with iCloud synchronizing for family access. The app will then send a notification to the user's device with the sound of a BEEP grabbing the user's attention the BEEP sound designed to the apps publishment of notifications automatically sends a message to the user that BEEP sent a notification meaning their food is about to expiry.

Despite this app's current features, it does not present any reasoning as to why an app like this is of beneficial use. What I have gathered from this app is that there is no motivating engagement factor such as bringing to people's attention the vital causes of food waste.

The app has a reliance on the barcode scanning feature for obtaining expiration date information on food items. This method may not work for all food items such as homemade goods, potentially leading to incomplete inventory tracking. There are privacy concerns with this app regarding the iCloud synchronization feature, without a doubt this is a convenient feature for family sharing, despite this beneficial feature there are concerns regarding the privacy and security of data, especially when dealing with sensitive information like household food consumption and waste patterns. Again, with iCloud synchronizing it can sometimes be problematic, leading to inconsistencies across devices views of the inventory meaning the app can present incorrect information.

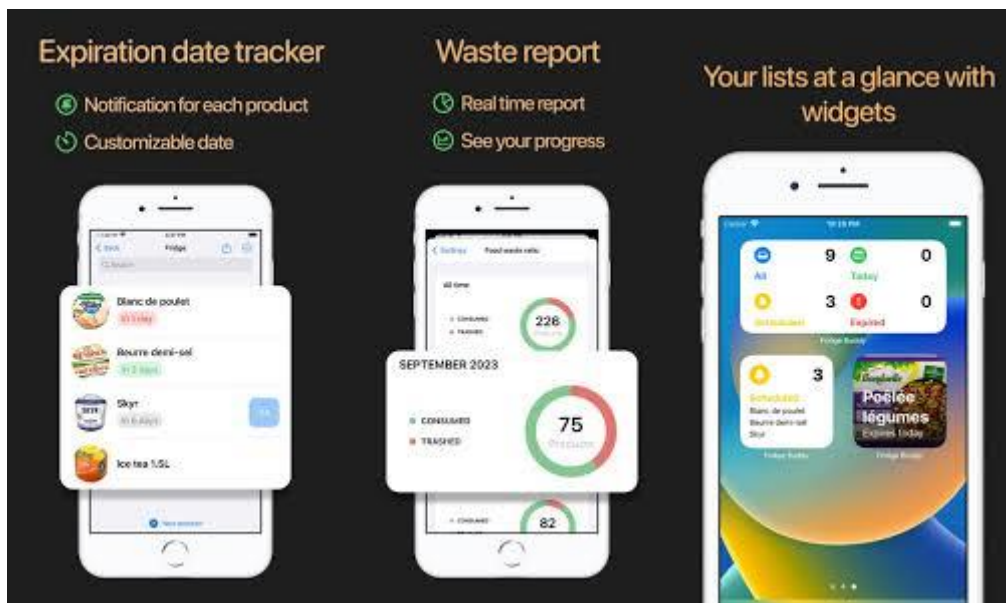
The BEEP notification makes this an attention drawing app however it is not suitable for users with hearing impairments which does not make this app of a visible use for some users with these particular limitations. However, it lacks motivational features, does not educate users on food waste reduction.



Pantry inventory, track food

“Pantry inventory, track food” this app's slogan is “Reduce waste Save money” highlighting to people the benefits of food recycling to persons bank account and the beneficence of this towards the planet. This app consists of quick inputs of food expiration dates with the use of a barcode scanner, the app retrieves product-related information like name, photo, and pre-filled expiration date. The app also has features such as customisable notifications and has a smart list which groups products into categories. There's also a widget to view this all quickly.

This app offers several useful features for managing pantry inventory and **reducing** food waste. However, the app does need some improvement. This app has limited customization; the app should allow easy manual adjustments. The widget feature is useful however there is potential the widget would contain information overload with excessive notifications and a cluttered, messy widget could confuse users leading to lack of engagement due to frustration. The app's slogan “Reduce waste Save money” oversimplifies the complex issue of food waste, leading to the neglect of important aspects such as proper food storage techniques or portion control. Overall, the app's message reduces food waste to a financial issue, overlooking environmental and social dimensions.

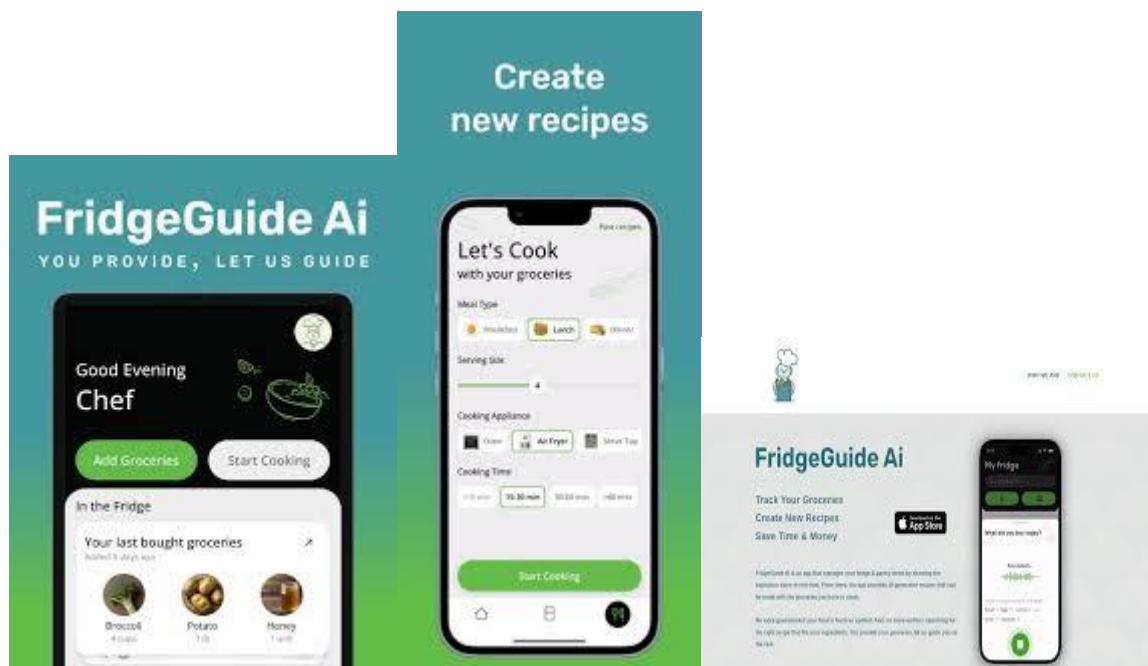


FridgeGuide Ai

FridgeGuide Ai this app is a bit more advanced as it scans food expiry dates and then sorts them by an auto-categorize section. An extra feature I discovered that stood out from the other apps was that it creates recipes.

There is also a grocery management feature that enables users to use their food to input their shopping list with voice recognition. Ai then organises the foods into category's making this a time saving app feature. Even though Ai has become such a useful newly introduced feature in our modern technological world this over-reliance in the app this makes users dependant on the app reducing their own decision-making skills and food knowledge.

Voice recognition is a very easy and useful engaging feature for many users. However, there are limitations as the voice-input may not always transcript correctly especially with diverse accents and background noises potentially leading to errors with regards to the shopping list and potentially leaving users frustrated due to the incorrect shopping lists disengaging users. Another major critical disadvantage to the app is that it beholds a paywall barrier, limiting the access to premium features preventing non- subscribed users from accessing the apps full functionality. FridgeAi offers innovative solutions for food management however this dependence on computer-based innovation should be considered while evaluating its overall human interpretation effectiveness and user experience.



Brief Analysis of Other iOS Applications

- **Food Organizer-Pantry Kit**

This iOS app offers a clean and well-structured approach to managing food storage. Users can organise items into customisable baskets, enhancing pantry organisation. It also includes a grocery list management feature and supports iCloud synchronising across devices for seamless access. A barcode scanner is integrated to make inputting food items and tracking their expiration dates more efficient. However, it, lacks any gamification or social engagement features, which are critical to supporting long-term behavioural change.

- **Freshly**

Freshly provides the core functionality expected from a basic food expiration tracking app. While minimal in design and features, it serves as a helpful reference model for establishing the foundational structure of my own app. Key features include categorisation, expiry notifications, and a simple interface suited for quick tracking, but it lacks deeper engagement mechanisms and community features

- **Floxx: Scan, Save & Simplify**

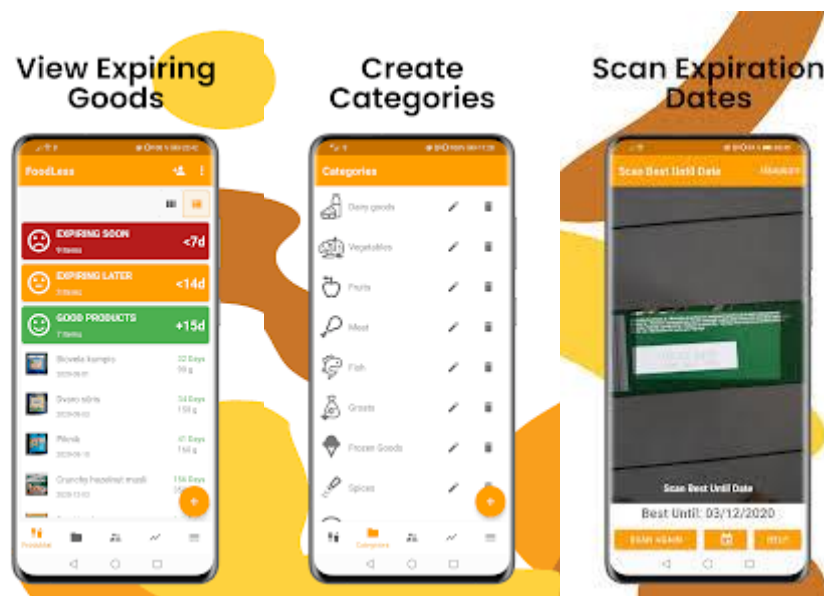
Floxx is a QR code scanning app that focuses on simplifying the organisation and management of various items. Its versatile use cases make it adaptable for food inventory purposes. The app shares similarities with other tools identified in this analysis, particularly in terms of scanning and categorisation features. However, this app also has no educational or motivational factor.

Android Analysis

Freeco - Food Expiry Date Reminder & Food QR Scanner app, I discovered this app on Android, the objective of the app is to help reduce food waste and reduce space waste due to the food packaging.

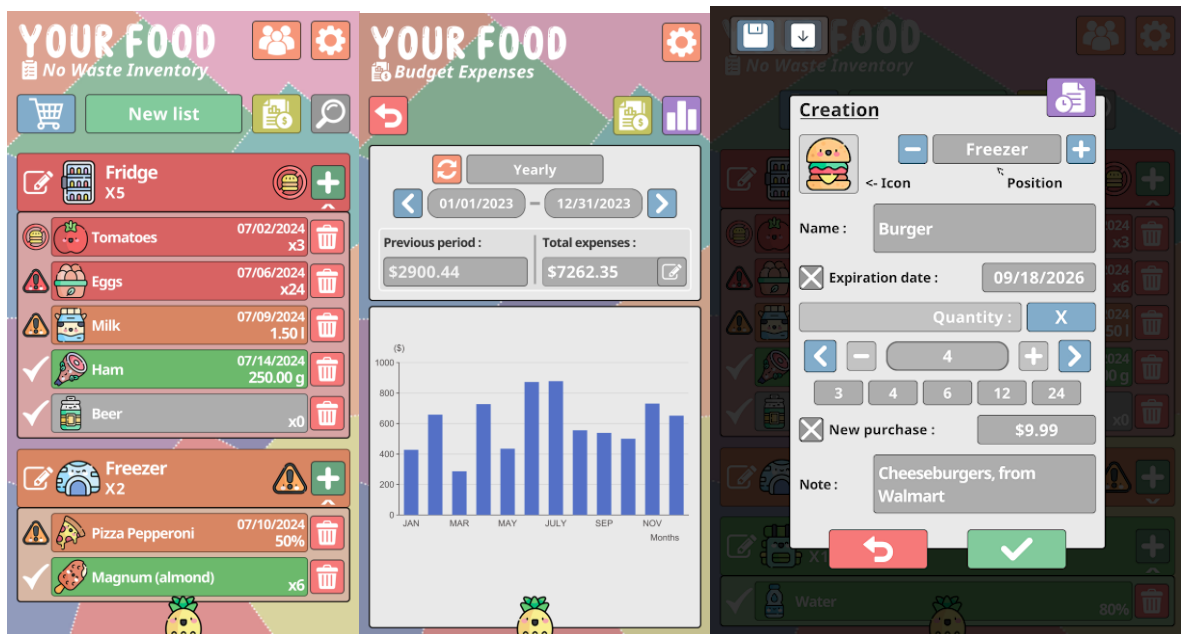
The app allows users to store the information by categories, e.g., meat, cheese, vegetable, etc. Also, you can save the information about the expiry date, quantity, and preparation information such as the time, temperature, device, etc. Saving the information in the app will allow you to throw away the food packaging as you will not need the information located on the packaging. The app also lets you do this for foods that you have prepared yourself and want to store the food for preservation. The app then generates a QR code for this food through the app, the user can then print this out and stick it to the food they are wanting to preserve. There is also a Smart Shopping List feature which allows users to add products that they want to repurchase where they can easily add this again to their shopping list.

Food waste impacts the environment however encouraging users to print QR codes for homemade foods could lead to unnecessary paper waste, contradicting the apps' goal of reducing food waste.



Your Food: A New Way to Organize Your Home & Reduce Food Waste!

The mechanism of the app is towards budget tracking and expiry reminder. The app provides a search bar for easy access to products that users are seeking quick information on. The app has an option to sort items by their name and quantity and another option to confirm deletion of items, in the application settings. The app automatically adds items to the shopping list (open creation screen) when their quantity reaches zero (disabled by default). The app allows switching inventory and logging into your account no longer requires restarting the app to correctly display the status of your items making this an easily accessible application. However, it does not provide features for social food-sharing or learning about sustainability.



1. Mobile Applications as Behavior Change Tools

The study *Food Talks Back: Exploring the Role of Mobile Applications in Reducing Domestic Food Wastage* highlights how mobile technologies can drive meaningful reductions in food waste. Three key applications were examined:

- Fridge Pal: Assists with household food management, tracking supply and expiry dates
- LeftoverSwap: Facilitates anonymous food sharing
- EatChaFood- Combines food tracking with social interaction and sharing
- MySusCof (MySusCof, n.d.).

These apps enhance users' food supply knowledge, food literacy, and enable peer-to-peer sharing showing the potential of tech-based solutions in driving sustainable habits. Their findings support the approach used in "*Imperfectly Fresh*," which similarly blends tracking, sharing, and user engagement

Insights from Analysis

Based on the evaluation of iOS and Android food expiration applications including "BEEP," "FridgeGuide AI," "Pantry Inventory, Track Food," "Freeco," "Freshly," "Food Organizer-Pantry Kit," "Floxx," and "Your Food" I have formulated several key insights which have emerged. These insights helped gain recognition on limitations and inform the development of a more innovative and user-centred solution.

1. Lack of Motivational and Gamified Features

A reoccurring pattern across many of the reviewed apps is the absence of gamification or motivational factors. The analysis consisted mostly of apps with the core functionality of barcode scanning, expiry tracking, and inventory organization however despite this there is long-term user engagement is limited. For example, while apps like "BEEP" only offers engagement of unique notification features, it does not motivate users beyond this point. In contrast, a food expiry tracking app that demonstrates integrating rewards and visual progress tracking can increase user participation by appealing to intrinsic motivation and a sense of achievement.

The integration of gamified features such as eco-points, badges, or challenges could significantly enhance daily engagement, particularly among students who are more likely to respond to interactive and rewarding experiences. Gamification can also serve to raise awareness about the environmental and economic impact of food waste, supporting both learning and behaviour change in a more engaging manner.

2. Limited integration of Behaviour Change and Food Education

Many apps focus solely on logistical food tracking and lack an educational component and fail to incorporate behavioural change frameworks. Leveraging behavioural theories like the **Theory of Planned Behaviour (TPB)** could be a strong foundation for building meaningful, habit-forming features.

3. No Unified Solution Offering Forecasting, Sharing, and Sustainability Support

Despite the various core functionality strengths across the apps, no single application reviewed successfully combines features like smart expiry forecasting, food sharing, and sustainability-focused behaviour support in one cohesive platform. For example, FridgeGuide Ai introduces smart recipe generation and voice-enabled list management but falls short in supporting food-sharing communities or visualising environmental impact. Similarly, LeftoverSwap and FoodSharind.de are focused on community food sharing but lack robust personal inventory tools.

This fragmented landscape points to a clear opportunity for an all-in-one app that combines personal food management, community sharing functions, and smart data tools which ultimately create a platform that not only reduces waste but actively encourages collective and individual responsibility. This is a clear opportunity to merge these strengths into a unified, multi-functional tool.

4. Syncing, Accessibility and User Interface Design, Over-reliance on Barcode Scanning

During my analysis, many user reports consisted of frustration with cloud syncing, poor accessibility, with outdated interfaces. For example, “BEEP”’s iCloud syncing is useful for sharing inventory across devices however there is concerns about data inconsistency and privacy. Additionally, the unique notification sound feature may not be inclusive of hearing-impaired users, indicating a lack of universal design principles.

On the Android side, “Freeco” introduces an innovative way to eliminate packaging by digitizing food labels via QR codes, however it may generate paper waste through excessive printing which undermines its eco-conscious goals.

“BEEP” and “Pantry Inventory” rely heavily on barcode scanning to input expiry dates. This is effective for packaged goods. However, this feature is ineffective for homemade goods or unlabelled items, leading to incomplete tracking.

To address these usability gaps, *Imperfectly Fresh* prioritises clean, responsive interfaces, inclusive design, and reliable cross-device synchronising that ensure both functionality and trust in the app’s accuracy. *Imperfectly Fresh* beholds an easy manual input option along with a text recognition scanner providing users with a flexible and user-friendly experience across different types of foods items.

Chapter Conclusion

The analysis findings highlight that while many current apps on the App Store and on Google Play offer useful tools for inventory and expiry management, they lack depth and emphasis on the food wastage issue, it also lacks user engagement which is required to create real behaviour change especially amongst students. By addressing these gaps into “*Imperfectly Fresh*” making it more comprehensive, gamified, and user-centric application that promotes not only food waste reduction but also greater awareness, responsibility, and sustainability in a unique engaging fun interactive way.

Design Process

Design Process: “*Imperfectly Fresh*”- A Sustainable Gamified Food Tracking App

The design objectives were directly derived from both the literature review and comparative app analysis conducted earlier in the project. Through the literature, it became clear that food waste among students is often linked to behavioural and logistical challenges including forgetfulness, lack of planning, and poor food visibility (La Barbera et al., 2022; Van Alboom, 2021).

https://drive.google.com/file/d/1qldWqmryBEJCHmF2PEhV8Dqg1cw83JYx/view?usp=share_link

Core Requirements

The foundational design objectives were to ensure that “*Imperfectly Fresh*” is simple and easy to use user interface tailored to student lifestyles.

1. Collaborative Food Sharing/Exchange Feature: Enhancing Sustainability Through Student Community Engagement

One of the most innovative and socially impactful of “*Imperfectly Fresh*” is the collaborative Food Sharing Feature. This feature directly aligns with one of the apps core design objectives: to enable smooth sharing and interaction within user communities, especially among students. This collaborative exchange functionality allows users to redistribute excess food items within groups e.g. (students of the course Digital Humanities & Information Technology), reducing food wastage while fostering a sense of shared responsibility and environmental awareness.

This group-based system operates through the formation of collaborative food exchange foods, where users have the option to post, claim or offer surplus food that is still consumable but at risk of being wasted. The groups can be organised can be organisation in the sense of a student accommodation or amongst friends or academic cohort e.g. “Final Year DH & IT Food exchange” encourages peer-to-peer sharing and cooperation within an existing social circle. The intention is to provide a trusted environment where users can comfortably exchange items without stigma or inconvenience.

This model is effective in tackling the issue of food waste in multiple ways. It facilitates redistribution, ensuring that food which might otherwise spoil is redistributed to someone else who can use it before it spoils. This Food sharing engagement overall increases the overall efficiency of food consumption within a shared network. It also raises awareness about the scale and preventability of food waste. As users actively track what they give or receive, they become more conscious of their consumption habits and are more likely to plan future shopping better.

This feature is particularly targeted at students, due to food wastage in student accommodation where food duplicated purchases often happen, irregular eating habits, or financial pressures. The food exchange not only contributes to sustainability but also has a factor of relief which can ease financial worries as the food group would enable students to plan their weekly grocery shop more efficiently. This encourages students to share what they do not need and helps reduce overbuying. Students learn about portion control, storage methods, and expiration tracking through a real-life interaction with other students. Over time, users gain knowledge, and it accumulates more efficient consumption behaviours and heightened environmental consciousness.

Encouraging Collective and Community-driven Action

From a systemic perspective, collaborative food exchange contributes to efficient food distribution. It connects those with surplus to those in need, reducing the likelihood of edible food ending up in the bin. This, in turn, contributes to lower household waste output and reduces the environmental footprint of food production, processing, and disposal.

The app reinforces the idea that reducing food waste is not just an individual task it is a collective responsibility. By embedding this community-driven feature, *Imperfectly Fresh* supports the development of micro food-sharing ecosystems, which together contribute to broader goals of food sustainability and circular consumption (Zachisson and Boks, 2012)

Integration with Gamification: User Status and Visual Progress

To further incentivise participation in the food exchange feature and promote consistent engagement, users are assigned a statues tier based on their weekly behaviours. Each time a user makes a sustainable choice, whether using other sharing food, they gain progress points that influence their tier level

Imperfectly Fresh tiers-based rewards system



- Tier 0: Food Slacker: This tier is given to users when they have left their food expiry by the end of the week meaning this have not participated in the apps and have wasted food and have not made any efforts to make better sustainable food choices.
- Tier 1: Food novice: This is the stage where users are starting to engage with the food expiration app and start to participate in the app's values and concepts.
- Tier 2: Food Advocate: Once the user receives this status, they have become more aware about their food choices and consumption patterns. This is the stage where the user starts prioritising sustainable food choices.
- Tier 3: Food Warrior: This is the highest tier of status a user can obtain. This status is given to individuals who are deeply committed to their food choices. They are highly informed, and their weekly choices has made an environmental impact and are promoting ethical food practices.

Each tier is visually represented with a unique icon, which evolves as the user progresses with their food consumption and food sharing habits. This gamified visual feedback provides immediate recognition of the user's status and encourages them to maintain or improve their level. The changing icon taps into psychological motivators such as the need for achievement, visual gratification, and personal growth. Each tier is assigned an icon which serves as a goalpost. The tiered icons create a clear roadmap from starting awareness Tier 1 to active engagement Tier 2. Users are encouraged to strive for these ranks, not just for visual awards but also for the sense of personal achievement they represent

Gamified Icons as Motivators

The analysis chapter emphasised how gamified features, such as rewards and reinforcements, could be helpful for motivating engagement in effective food waste reduction. The implementation of gamified, evolving icons in *“Imperfectly Fresh”* is not only a stylistic choice, but it also acts as a powerful behavioural design tool rooted in both psychology and gamification theory. These elements align with service-based gamification models, where ongoing user engagement is maintained by providing functional and emotional value through the experience (Huotari and Hamari, 2011). These icons visually represent a user's status tier, based on their ongoing commitment to reducing food waste through either using or sharing food before it expires. As users progress from lower to higher tiers, moving from “Food Slacker” to “Food Warrior” icon associated with their profile changes accordingly. This subtle yet strategic use of visual gamification supports several cognitive and motivational principles that significantly enhance user engagement.

To support user engagement and promote sustainable food habits, *Imperfectly Fresh* implements a simple yet effective points-based reward system. Users earn points based on their food-related actions within the app:

- **"Use it" — +2 points:** Awarded when a user consumes food before its expiration date.
- **"Share it" — +1 point:** Given when a user redistributes excess food through the app's sharing feature.
- **Expired food — 0 points:** No points are awarded when food expires, and it is automatically removed from the user's inventory.

These points contribute to the user's **tier status**, which reflects their overall engagement with the app and commitment to food sustainability. The tiers are structured as follows:

- **Food Slacker** – 0 points
- **Food Novice** – 2 points
- **Food Advocate** – 4 points
- **Food Warrior** – 10+ points

Each tier is represented by a unique visual icon that evolves as users progress. This visual feedback mechanism enhances motivation by providing a clear sense of achievement and encouraging continued participation.

Currently, tier visibility is private, allowing users to monitor their progress without external comparison. This design choice supports intrinsic motivation, focusing on personal growth and habit formation rather than competition. This gamification approach draws on operant conditioning principles using from the B.F Skinner theory. In Skinners model, behaviours that are followed by rewarding outcomes are more likely to be repeated. *Imperfectly Fresh* adapts this approach with this structured point system.

The use of these gamified icons gives users visual feedback. As users take positive actions like using food before it expires or sharing it through the Collaborative Food Sharing feature their icon evolves to reflect their efforts. This feedback loop is instant, visible, and deeply satisfying, tapping into the brain's dopamine reward system. The gamified changing icon feature acts as an intuitive signal of achievement. This instant recognition reduces the cognitive effort required to assess progress and keeps the user engaged with minimal friction. It plays a central role in creating a sense of progression, a key element in sustaining user motivation over time. The visual shift from icon tier to another signal's advancement and mastery.

One major source of information for this feature was the rewards system used by Duolingo. Duolingo's language learning platform encourages daily engagement through streaks, badges, and evolving profile icons, which visibly track a learner's progress. What resonated with me was how these elements offered non-intrusive, motivational nudges to keep users committed to their goals. Much like Duolingo encourages users to return daily and maintain their streak, *Imperfectly Fresh* uses icon progression and tier status to encourage ongoing participation in food-saving behaviours. This insight helped shape the idea that sustainability, much like language learning, benefits from small, consistent actions, which can be reinforced through visual milestones.

This psychological motivating factor is often referred to as competence motivation which is vital for habit formation (Deci & Ryan 2000). When users visually see how far they are progressing, they are more likely to persist in the behaviour, working towards the next stage of progression. "*Imperfectly Fresh*" rewards users if they behold consistent effort and encourage users to maintain their momentum to protect and further develop their symbol of personal investment. As users move through the app, their icon becomes a visual marker of their journey, reflecting on the user's time, effort, and intentionality they have dedicated to improving their

food habits. This aligns with the principle of endowment effect users place more value on things they feel personally connected to or responsible for (Kahneman et al., 1990)

By allowing users to “own” their sustainability journey through a personalised icon, the app deepens emotional engagement. The more the user sees themselves in the icon, the more likely they are to value it and work to protect or improve it.

With the implementation of the tiers-based rewards system, diverse food utilisation is encouraged, as users could find creative uses for foods, they might not have bought themselves. This prevents ingredients near expiration from being thrown away due to lack of perceived value. Users who engage in the food coloration sharing feature of “*Imperfectly Fresh*” would learn from one another, building knowledge around food preservation and best-before date interpretation which both enhance long-term sustainable habits. (Yu, Qian and An, 2023)

This entire structure is heavily influenced by B.F Skinner's theory of operant conditioning (Skinner, 1938), where behaviour is shaped through reinforcement. In “*Imperfectly Fresh*,” each time users make a sustainable choice, they receive a reward (icon), reinforcing that behaviour and increasing the likelihood of it being repeated. This use of positive reinforcement is subtle but effective, it does not interrupt the user flow, yet it rewards meaningful engagement.

As Lewis, Swartz, and Lyons (2016) state, gamification can act as an intervention strategy to enhance intrinsic motivation. By making behaviour change fun and personally meaningful, users are more likely to integrate those behaviours into daily routines, even after the novelty of the app wears off.

Overall, the gamified icon system in “*Imperfectly Fresh*” acts as an anchor for engagement, a motivator for change, and a visual storyteller of the user's journey. The design of this rewards system has the combination of emotional connection, visual satisfaction, and goal-oriented design into a single mechanic that promotes both sustainable action and sustained app usage.

I chose to design the rewards system in “*Imperfectly Fresh*” as a personal growth journey towards sustainability rather than a punitive or shaming approach because I wanted to encourage positive, lasting behavioural change in a supportive and empowering way. Inspired by gamification principles seen in platforms like Duolingo, where users are rewarded for progress rather than punished for failure, the tiered badge system promotes a sense of achievement and emotional connection to sustainable habits. In contrast, the “Grumpy Bin” design presented in the attached paper uses a more negative behavioural feedback loop, where users are publicly held accountable through sarcastic messages and social media posts that highlight their food waste. While the Grumpy Bin method of food reduction it can provoke reflection, it risks triggering shame embarrassment, which may be counterproductive, especially in shared student environments where peer dynamics are sensitive. This leads to negative behavioural change where the objective of the app dismisses the main concept of the application which is reducing food waste leading to users seeking achievement over other users. *Imperfectly Fresh* instead focuses on intrinsic motivation and habit reinforcement through visual progress, encouraging users to reflect on their behaviour without the fear of judgement.

Software and Hardware for Coding *Imperfectly Fresh*

iOS vs Android: Why I chose iOS Over Android for developing *Imperfectly Fresh*

In the early stages of designing *Imperfectly Fresh*, a key decision was determining the most suitable platform for development which is the decision whether to develop an iOS or Android application. After evaluating the requirements of my application, its intended audience, and the available development tools, I chose to build *Imperfectly Fresh* as a native iOS application. This decision was based on both practical and strategic considerations related to performance, development efficiency, design integration, and user experience.

One of the biggest advantages of iOS over Android is the lack of device fragmentation. Apple's closed ecosystem allows developers to create apps for a limited range of devices, all of which share similar hardware capabilities, screen sizes, and resolutions. This consistency streamlines the design and testing process, reducing the time needed to debug and optimize the app across countless configurations.

Whereas Android applications face the challenge of building for an enormous variety of devices made by different manufacturers. Ensuring consistent performance, appearance, and behaviour across these devices can be time-consuming and technically demanding. Given the deadline and scope of my project, iOS was the more practical and manageable choice.

Xcode and Swift Ui

Apples Xcode IDE (integrated Development Environment) provides a comprehensive and efficient platform for designing, developing, and testing iOS apps. It offers advanced features such as predictive code completion, live previews, interactive animations, and an iOS simulator. These tools help developers build interfaces quickly and safely, with the help of on-device machine learning models trained specifically for Swift and Apple SDKs.

Working with Swift Apples's modern, safe, and expressive programming language and SwiftUI a declarative UI framework enables me to build the logic and interface for "*Imperfectly Fresh*" with security, confidence, and flexibility. SwiftUI's live previews enabled me to see immediate results from Ui changes, saving development time and improving accuracy.

I supported my introduction to Xcode and Swift through self-learning platforms such as "Code with Chris," which provided accessible, beginner-friendly tutorials on using Auto Layout, managing project files, and navigating the Xcode interface. By choosing iOS I was able to take full advantage of the hardware and software integration that Apple offers to developers offering a smoother performance and more fluid user experience since the app is built using Apple's own frameworks and development tools, it integrates naturally into the iOS operating system. This was particularly important for a utility-focused app like mine, where usability and responsiveness play a major role in retaining users.

Since "*Imperfectly Fresh*" relies heavily on visual feedback, gamified progress indicators, and user-friendly navigation, iOS offers an ideal environment to implement these elements effectively.

Developing with iOS also aligned with my academic and professional development goals. By focusing on Apple's tools and technologies, I gained practical experience in a skill set that is in high demand across the mobile development industry. Tools such as the iOS Simulator,

which allows for debugging and previewing app behaviour without needing a physical device, enabled me to test and iterate more efficiently during the early stages of development.

Additionally, literature such as *Creating iOS Apps: Develop and Design* by Richard Warren (2014) and academic case studies like *eRecipes: The Design and Development of an iOS Application* further reinforced my understanding of Apple's software ecosystem and the advantages of using native development practices for building robust and reliable applications.

The core concept of *Imperfectly Fresh* involves social sharing, real-time feedback, and community participation, which benefit from a responsive, well-integrated application structure. iOS enabled me to implement features like status tier updates, icon changes, and notifications smoothly, without the complexities of managing varying background processes across different Android versions and manufacturers.

Hardware requirements

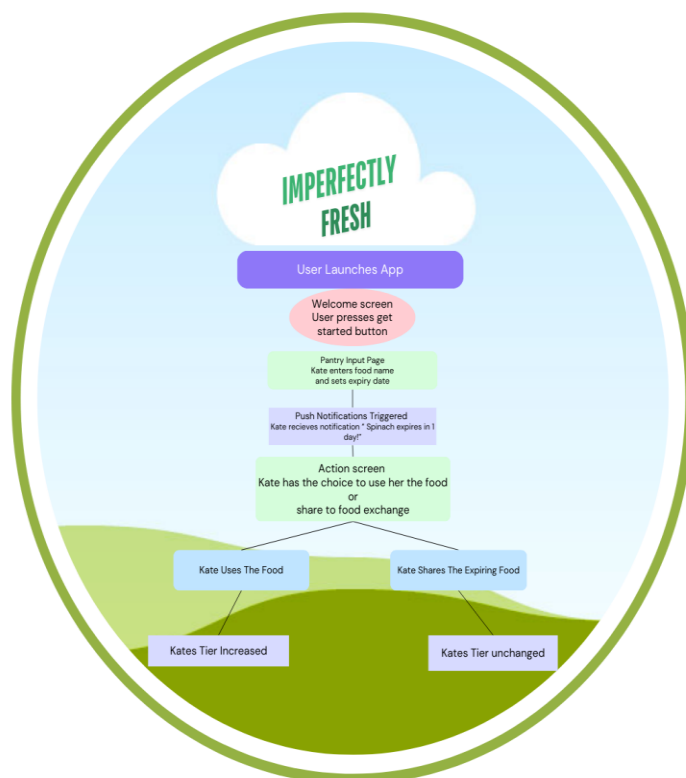
A MacBook (macOS Ventura or later) is needed as Xcode is only available on macOS.

Wireframing and User Journey Mapping

The app design process stage is a crucial phase in the development of a mobile application. As the main objective if the design is focusing on creating a visually appealing and user-friendly interface. The process I carried out began with creating low-fidelity wireframes which outlines the basic structure and layout of the functionality of the app. The use of the low fidelity wireframes leads to refined into high-fidelity versions, incorporating more detailed design elements and interactions. The most important thing is to ensure that every aspect of the app prioritizes user satisfaction with carefully selecting colour schemes, typography, and visual components that align with the apps information architecture, navigation flow and overall user experience (UX). These wireframing tools and user journeys are useful prototypes which help test and iterate the design of the apps interface. These steps develop apps that truly resonate with their target audience.

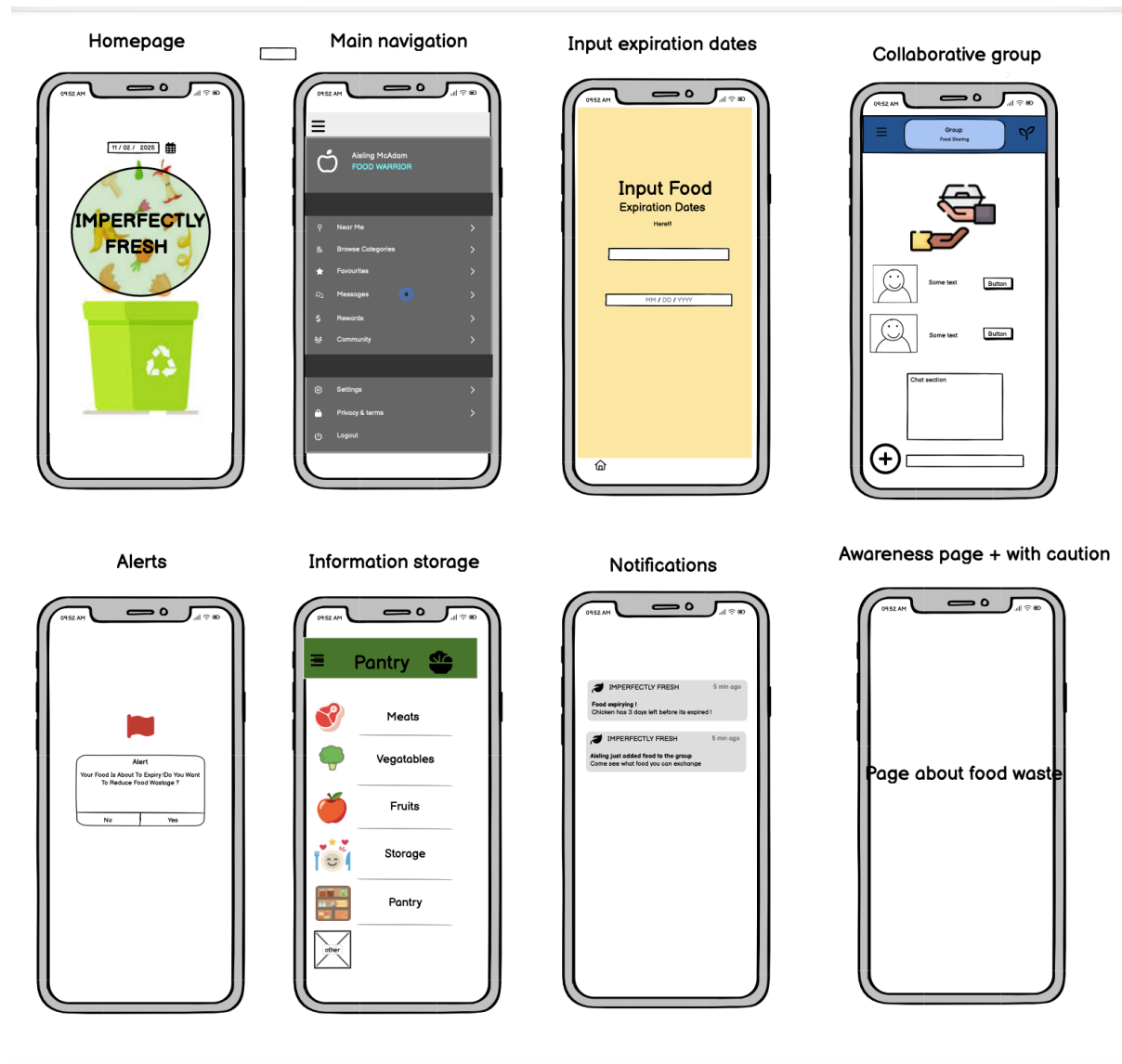
User Journey Map

The incorporation of a user journey mapping technique made using Canva in my app design process has been valuable tool in creating a successful and user-friendly application. The use of visually mapping out the steps a user takes while interacting with my app, has led me to invaluable insights into the motivation and needs and potential frustrations that could arise on the User interface.



Wireframing

Wireframes are basic, low-fidelity sketches of each screen's layout. I developed wireframes using Balsamiq to detail the placement of UI elements like text fields, buttons, images, and navigation components. For example, in *Imperfectly Fresh*, I designed wireframes for the Tracker page where users can input food items and access features like scanning a food label using VisionKit. I then created wireframes for each screen. For instance, the Tracker screen wireframe detailed where the text field for entering food names would be, the position of the scan button, the layout of the expiration date picker, and the placement of the "Add Food" button.



These are the initial wireframes I created to guide me during my development process. I created these in hope of steering me in the right direction and giving me some guidance on how I wanted the UIs to look like roughly. However, I implemented many changes in the final version of the application. These visual representations guided the subsequent development of the UI in Xcode and ensured that I maintained a consistent and intuitive user experience throughout the app.

In summary, the design stage encompasses everything from early research and ideation to storyboarding and wireframing. This phase is crucial for setting a strong foundation, ensuring that the final implementation meets both functional requirements and user expectations.

User Interface (UI) Design

Using SwiftUI, I designed the interface with these principles:

- Consistency: Shared layout styles (e.g. rounded buttons, gradient backgrounds)
- Clarity: Key actions like “Add Food” or “Share It” are prominently displayed
- Colour Coding: A light green palette reflects freshness and sustainability, while gentle gradients enhance visual appeal.
- Typography: Readable, clean fonts with hierarchy between headers and content
- Responsiveness: Auto Layout principles ensure compatibility across iPhone sizes.

4. User Experience (UX) Flow

The app’s UX was designed around **minimizing user effort**:

- Users can scan food labels using **VisionKit** to quickly input items.
- Expiry dates are selected with a simple DatePicker.
- Items are automatically categorized using keyword recognition.
- Pantry clearly view groups food and offers two primary actions.
- Tier points are immediately reflected when actions are taken, reinforcing behaviour.

5. Gamification Design

A point system was implemented where:

- **"Use it" = +2 points**
- **"Share it" = +1 point**
- **Expired = 0 points (and auto-removal)**

Points contribute to user tiers:

- **Food Slacker (0 pts)**
- **Food Novice (2 pts)**
- **Food Advocate (4 pts)**
- **Food Warrior (10 pts)**

Tiers were made visually appealing with icons, colours, and emojis to create a motivating experience.

6. Tools and Technologies

- **Xcode**: Used as the development environment.

- **SwiftUI:** Framework for building responsive, declarative interfaces.
- **Canva/Figma (Optional):** Used to draft early design concepts and visual themes.
- **Preview & Simulator:** Xcode previews enabled live visual testing of layouts and animations.
- **VisionKit & VNDocumentCameraViewController:** For scanning labels and extracting food information.

7. Design Evaluation

Before implementation, early versions of the design were tested with peers to collect usability feedback. This helped refine:

- Button placement
- Font size readability
- Navigation clarity
- Tab bar labelling

Green Theme Indicating Sustainability

The design process played a central role in shaping the app's implementation. Insights from competitors' analysis and user journey mapping informed layout choices and feature prioritization. The use of a green theme was intentional, symbolizing freshness, sustainability, and eco-awareness. The palette reinforces the app's environmental mission and provides users with a visually calming and consistent experience, reminding them of the importance of sustainability in daily habits.

Code was structured to support maintainability, with reusable components for UI and shared logic. Testing with Xcode's simulator ensured UI consistency across screen sizes. Regular testing phases allowed for identifying logic bugs and improving feature responsiveness.

App Icon Creation

The home screen icon for Imperfectly Fresh was created using Canva, a user-friendly design platform that allowed for precise vector shaping, colour gradients and icon layering. Once the design was finalised, I resized the graphic to 1024 x 1024 pixels to meet Apple's iOS app icon specifications. This ensured the icon would scale correctly across devices.

The icon's design carries meaningful symbolism that aligns closely with the app's core purpose. The circular arrows represent the concept of recycling and food reuse, a nod to the app's emphasis on reducing food waste. The bowl shape suggests consumption. Integrated within the design are leaf elements, which evoke ideas of sustainability, freshness, and ecological responsibility key values that the app promotes through both its functionality and user messaging. The icon communicates the essence of *Imperfectly Fresh* at a glance which is a sustainable, food sharing, and waste reduction in a visually appealing and meaningful way.



Conclusion

The design process for *Imperfectly Fresh* was iterative and user-focused, balancing visual appeal with functionality. Through thoughtful wireframing, storyboarding, and SwiftUI implementation, the final design supports the app's goal of encouraging sustainable food habits in a way that is engaging, educational, and easy to use.

Implementation

The implementation stage is a vital phase in the mobile app development lifecycle, marking the transition from ideation and design to a fully functional product. For “Imperfectly Fresh,” an iOS application focused on reducing food waste through expiration tracking and sharing, and gamification, this stage involved transforming well-research design specifications into a user-centric, sustainable digital solution. The app is particularly geared towards students, enabling them to manage their food more responsibly while fostering community-based collaboration through collaborative food sharing groups and tier-based rewards system.

The creation of Imperfectly Fresh follows a structured and methodical approach, designed to ensure responsiveness, and a cohesive user experience. I began by translating the wireframes and user journey designs into a working iOS application using SwiftUI for declarative user interface development and Xcode as the primary integrated development environment (IDE). Key attributes to the app are food tracking, food sharing and progression monitoring. The choice of tools was crucial to ensuring the app would perform responsively, maintain a clean interface, and support dynamic features such as real-time food tracking, visual rewards, and student community interaction.

The foundation of “Imperfectly Fresh” was grounded in extensive research on environmental, economic, and social impacts of food waste. My inspiration from scholarly sources and case studies, I ideated a concept that not only addresses these issues but also integrates behavioral motivation and social collaboration, two underutilized features in existing food-tracking apps (Smith & Jones, 2020).

Imperfectly Fresh’s Core Functionalities:

- Manual and automated food item tracking
- Expiration reminders and smart categorization
- A community exchange system for sharing excess food
- A gamified rewards system based on sustainable habits

The ideation phase was guided by Richard Warrens (2014) *Creating iOS Apps: Develop and Design*, emphasizing early prototyping, storyboard mapping, and rapid iterative testing.

Development Tools and Environment

Xcode and the iOS Ecosystem

Xcode and SwiftUI were chosen for their seamless integration into the apple ecosystem. Xcode Apple’s integrated development environment (IDE) offers a full suite of tools for designing, testing, debugging iOS applications. Key features such as predictive code completion, live previews, animations, and the iOS simulator allowed me to iteratively develop and test the app on different devices without the need for physical hardware. Xcode’s integration with Swift and SwiftUI streamlined the development process, especially with the visualization tools that helped bring design and elements to life.

SwiftUI, Apple's declarative UI framework, made it easier to build responsive interfaces with minimal boilerplate code. Components such as VStacks, HStacks, ZStacks, and the use of state-driven views helped manage UI logic. The use of SwiftUI also allowed for better control over design consistency and responsive layout adaptation across screen sizes.

Key Functionalities

The creation of Imperfectly Fresh was modularized into core components:

- **Food Tracking**
Users can enter items manually or use VisionKit for optical text recognition to detect expiry dates. This feature allows for quick and efficient food logging, addressing one of the key barriers to regular app usage (Richard, 2014).
- **Expiration Reminders and Categorization**
Smart groupings help users prioritize expiring food, enabling better planning, and reducing the likelihood of forgotten or spoiled items.
- **Student Food Sharing**
A collaborative feature enables students to exchange food within trusted student groups. This system fosters a culture of sustainability, reduces financial burden, and supports peer-based food redistribution.
- **Gamified Rewards System**
A tiered badge system reflects user engagement and promotes sustainable behavior. Users earn points by taking responsible actions such as food sharing or using food before expiry which then is reflected in their tier's status (e.g., Food Novice to Food Warrior). This system draws from psychological motivators to encourage long-term behavioral change.

Together, these components deliver a cohesive experience that supports both individual accountability and community-driven action against food waste.

Xcode: Apple's IDE

Xcode is Apple's official development environment used to build software across all Apple platforms, including iOS, iPadOS, macOS, watchOS, and tvOS. It provided a comprehensive suite of tools for the development of Imperfectly Fresh, including:

- **Code Editor:** With syntax highlighting, auto-completion, and real-time error feedback for Swift Code which helps detect error in early stages of coding and throughout.
- **Interface Builder:** Visually constructed and previews the apps interfaces.
- **IOS Simulator:** Enabled the testing of imperfectly Fresh on a virtual device without needing a physical device.
- **Build and Debug Tools:** Includes powerful diagnostics for performance, memory usage, crash analysis was useful for tier icon integration.
- **Asset Mangement:** Organizes image files and media across resolution variants.

Xcode's tight integration with the Apple ecosystem made it easier to deploy, test, and refine Imperfectly Fresh across different device sizes and iOS versions. Its live preview capability

enabled iterative development, where changes to layout and logic were rendered in real-time, drastically improving development speed.

Swift and SwiftUI: Declarative Interface Design

Swift is Apple's modern programming language, known for its readability, safety, and performance. It integrates seamlessly with SwiftUI, the declarative framework used to build Imperfectly Fresh user interface.

SwiftUI enabled to define Imperfectly Fresh with a declarative syntax, meaning the UI is described based on the state of the app rather than explicitly defining every change. This results in cleaner, less error-prone code and facilitates powerful dynamic views. Key features included:

- `@State` and `@Binding`, Swift property wrappers that manage view state and allow data to flow between components.
- `@EnvironmentObject`: Used for sharing data (e.g., tier status, pantry inventory) across multiple views without excessive boilerplate
- `VStack`, `HStack`, `ZStack`, these are layout containers for arranging elements vertically, horizontally, and layered.
- `List` for `Each`: Components for rendering dynamic content like inventory items or progress history.
- `NavigationStack` and `Tab View`: Provided hierarchical navigation and multi-tab functionality.
- `DatePicker` and `Text Field`: Used for user input when entering food items and expiration dates.
- `Image` (system Name :) and `SF Symbols`: Leveraged to provide clean, scalable icons for the tier system and navigation.

Swift and SwiftUI allowed for the creation of a modular, maintainable codebase, where views could be updated reactively in response to user actions or changes in data.

Xcode Environment and SwiftUI Implementation

```

1  //
2  //  TiersView.swift
3  //  fixes
4  //
5  //  Created by Aisling McAdam on 24/03/2025.
6  //
7
8  import SwiftUI
9
10 struct TiersView: View {
11     @Binding var points: Int
12     @State private var userTier: UserTier = .foodSlacker
13     private let resetKey = "lastTierResetDate"
14
15     var body: some View {
16         NavigationView {
17             ZStack {
18                 // Light gradient green background
19                 LinearGradient(gradient: Gradient(colors: [Color.green.opacity(0.3),
20                     Color.green.opacity(0.2)]),
21                     startPoint: .topLeading,
22                     endPoint: .bottomTrailing)
23                 .ignoresSafeArea()
24
25                 VStack(spacing: 20) {
26                     // Points Container (Bigger)
27                     VStack(spacing: 12) {
28                         Image(systemName: userTier.icon)
29                         .font(.system(size: 70))
30                         .foregroundColor(userTier.color)
31
32                         Text(userTier.description)
33                         .font(.title)
34                         .bold()
35                         .foregroundColor(.white)
36
37                         Text("Points: \(points)")
38                         .font(.title2)
39                         .bold()
40                         .foregroundColor(.white)
41
42                         ProgressView(value: progressValue(), total: 10)
43                         .accentColor(userTier.color)

```

```

1  //
2  //  Pantry.swift
3  //  fixes
4  //
5  //  Created by Aisling McAdam on 24/03/2025.
6  //
7
8  import SwiftUI
9
10 struct PantryView: View {
11     @Binding var pantry: [String: [FoodItem]] // Receives categorized data
12     @Binding var points: Int // Points for the tier system
13     @Binding var foodPosts: [FoodPost] // Binding to update food sharing posts
14     @State private var showAlert = false
15     @State private var selectedItem: FoodItem? = nil // Holds the selected food item
16
17     var body: some View {
18         ZStack {
19             LinearGradient(
20                 gradient: Gradient(colors: [Color.green.opacity(0.8),
21                                         Color.green.opacity(0.4)]),
22                 startPoint: .topLeading,
23                 endPoint: .bottomTrailing
24             )
25             .ignoresSafeArea()
26
27             ScrollView {
28                 VStack(alignment: .leading, spacing: 20) {
29                     ForEach(pantry.keys.sorted(), id: \.self) { category in
30                         if let items = pantry[category], !items.isEmpty {
31                             Text(category)
32                                 .font(.title2)
33                                 .bold()
34                                 .foregroundColor(.white)
35                                 .padding(.horizontal)
36
37                             ForEach(items) { item in
38                                 Button(action: {
39                                     selectedItem = item
40                                     showAlert = true
41                                 }) {
42                                     HStack {
43                                         VStack(alignment: .leading, spacing: 5) {

```

```

1 //
2 // TextScannerView.swift
3 // fixes
4 //
5 // Created by Aisling McAdam on 24/03/2025.
6 //
7
8 import SwiftUI
9 import VisionKit
10 import Vision
11
12 struct TextScannerView: UIViewControllerRepresentable {
13     @Binding var text: String
14     @Binding var expiryDate: Date
15
16     class Coordinator: NSObject, VNDocumentCameraViewControllerDelegate {
17         var parent: TextScannerView
18
19         init(parent: TextScannerView) {
20             self.parent = parent
21         }
22
23         func documentCameraViewControllerDidFinish(_ controller:
24             VNDocumentCameraViewController, with scan: VNDocumentCameraScan) {
25             let scannedText = processScannedImages(scan: scan)
26             DispatchQueue.main.async {
27                 self.parent.text = scannedText
28                 if let detectedDate = self.detectExpiryDate(in: scannedText) {
29                     self.parent.expiryDate = detectedDate
30                 }
31             }
32             controller.dismiss(animated: true)
33         }
34
35         func documentCameraViewControllerDidCancel(_ controller:
36             VNDocumentCameraViewController) {
37             controller.dismiss(animated: true)
38         }
39
40         func documentCameraViewController(_ controller: VNDocumentCameraViewController,
41             didFailWithError error: Error) {
42             print("Scanning failed: \(error.localizedDescription)")
43             controller.dismiss(animated: true)
44         }
45     }
46
47     func makeCoordinator() Coordinator {
48         Coordinator(parent: self)
49     }
50 }

```

Modular Feature Development

Food Tracking

Users can add food manually or use VisionKit, Apple's OCR (Optical Character Recognition) API, to scan expiration dates directly from packaging. This integration required using VNDocumentCameraViewController, which provided a native scanning interface.

Expiration and Smart Categorization

Once entered, food items are grouped based on expiration date and they are automatically grouped. This feature was implemented with custom Swift structs and @State to manage categorization logic and live updates.

Community-Based Food Sharing

The sharing feature allows users within defined student groups to exchange surplus food. Using SwiftUI's navigation tools and conditional rendering, students can view, post, and claim food items.

Gamified Tier System

Points are awarded +2 for using food and +1 for sharing food, and the tiers update automatically using `@EnvironmentObject`. Each tier is visually represented by an icon, updated dynamically to reflect user's engagement level. This feature uses state-driven UI updates and provides visual feedback based on B.F Skinner's operant conditioning theory.

Technical Challenges and Limitations

Despite the powerful development environment that Xcode offers, the overall implementation had a few challenges and obstacles. However, I came across a website called Code with Chris which helped assist me on these challenges along with stack overflow which helped overcome challenges when there were setbacks within the creation of Imperfectly Fresh:

- Xcode Learning Curve: Initially, navigating Xcode's interface was quite difficult as I had no familiarity with it. I came across frequent errors in building processes (e.g., “redeclaration of variable”) and live previews slowed early progress and the simulator continuously “Failed to build” if there was one error within the code. This process was time consuming which consisted of patience and consistent focus on trying to run the code.
- State Management and Data Passing: One of the most persistent challenges was passing data between different UI components, particularly from the pantry view and collaborative group sharing view into the rewards system. Managing shared data across SwiftUI views using `@State`, `@Binding`, and `@EnvironmentObject` was complex. I had to reconstruct data models and state management strategies multiple times to ensure correct tier updates and consistency across screens. This process was the longest process as my rewards system changed visually multiple times.
- Debugging
- UI revisions: The UI design completely changed repeatedly throughout development. Early wireframes did not fully capture the needs however the wireframes did assist me on a UI design process guideline. I adjusted icon sizes, navigation layout, text hierarchy, and button visibility based on feedback. The reward icon designs were also iterated to ensure they were visually distinct, appealing, and aligned with the gamification logic. Multiple layout iterations were explored before finalizing a clean and visually intuitive interface tailored to students.

Chapter Summary

The implementation of “Imperfectly Fresh” brought together research, design thinking, and technical development into a cohesive and purposeful mobile application. Despite facing initial limitations, especially with state management, data sharing across views, and UI revisions, these challenges ultimately strengthened the final product. The app now includes a fully integrated system for food tracking, sustainable sharing, and gamified motivation.

While challenges around data flow and UI responsiveness tested the project's momentum, overcoming these barriers resulted in a more resilient, user-friendly application. The app has potential for new features such as cross-platform expansion, iCloud synchronizing, AI-powered expiry prediction, recipe suggestions, or in-app sustainability tips.

Ultimately, this stage reflects the constructive collaboration between technical tools and design thinking, offering a strong foundation for mobile interventions targeting food waste in student communities.

Evaluation

Evaluation of Imperfectly Fresh

Evaluation is an essential part of my design process. Although I initially designed Imperfectly Fresh based on insights generated from initial literature and app analysis, However, literature and app analysis alone cannot determine whether these features would be beneficial for supporting engagement in food waste in food waste management. In this evaluation, I focus not only on how well the app functions but also on how satisfying, enjoyable, and motivating the interactions are for users. The evaluation provides critical feedback that could inform a next iteration in design. It highlights issues or points I may have missed that makes the experience better for users, allowing me to refine the app continuously and ensure a better overall user experience for my target users of which who are university college students.

My research question “What features could be implemented in a food expiration tracking app that can promote food sharing amongst third level students, and how can these be implemented to encourage awareness in food waste?” —guides my evaluation efforts. I need to understand whether Imperfectly Fresh is not just usable, but if it genuinely becomes part of users’ everyday routines and contributes to a reduction in food waste.

For the purpose of creating the evaluation plan, I employed the DECIDE framework which is commonly used in Human-Computer Interaction (HCI). The DECIDE framework provides a checklist to help plan evaluation studies and guide to issues researchers need to think about. It has six following terms.

1. **Determine the goals:** Evaluate usability, engagement, and behavioural impact
2. **Explore the questions:** Investigate whether the app motivates sustainable habits, is easy to use, and fits into users' routines.
3. **Choose evaluation methods:** Usability Testing and post-use interviews
4. **Identify practical issues:** Limited time frame, small user group, and access to devices.
5. **Decide how to address ethical issues:** Ensured informed consent and user privacy.
6. **Evaluate, interpret, and present data:** Analysed feedback to refine the app and support future iterations.

Choose the Evaluation Methods

Usability testing

Typifying this approach to evaluating user interfaces, usability testing involves collecting data using a combination of methods i.e. experiments, observation, interviews, questionnaires in a controlled setting. It is generally done in laboratories although increasingly it is being done remotely or in natural setting.

The primary goal is to determine whether an interface is usable by the intended user population to carry the tasks for which it was designed for.

This involves investigating how typical users perform on typical tasks. By typical we mean the users whom the system is designed in this case for students and the things that it is designed for them to be able to do e.g. (share excess food). It often involves comparing the number and kinds of errors that the users make and recording the time that it takes them to complete the task. As users perform tasks, they may be recorded on video; their interactions with the software may also be recorded, usually by logging software.

User satisfaction questionnaires and interviews can also be used to elicit users' opinions about how they found the experience of using the system.

Observing users' reactions to an interactive product has helped developers understand usability issues that would be extremely difficult for them to glean simply through reading reports or listening to presentations.

For many years HCI usability testing has been a staple to HCI, being used in the development of standard products that go through many generations, such as word processing systems, databases, and spreadsheets (Mayhew, 1999; Hackos and Redish, 1998; Dumas and Redish, 1999; Koyani et al, 2004).

The findings from the usability testing are often summarized in a usability specification that enabled developers to test future prototypes or versions of the product against it. Changes in the design can then be implemented, such as navigation structure, use of terms, and how the system responds to the user.

Madrigal and McClain (2010) provide practical guidance including a list of dos and don'ts of doing usability testing. They point out how "Usability testing is one of the least glamorous, but most important aspects of user experience research". Experiments are typically conducted in research labs in universities or industry to test hypotheses. They are the most controlled setting, where researchers try to remove any extraneous variables that may interface with the participants performance.

Collecting data about users' performance on predined tasks is a central component of usability testing.

A user satisfaction questionnaire is used to find how users feel about using the product, through them to rate it along several scales after interacting with it.

Examples of the tasks that are given to users include searching for information, reading different typefaces, and navigating through different menus.

Time and number are the two main performance measures used, in terms of the time it takes typical users to complete a task such as the number of errors a participant makes, such as selecting wrong menu options when creating a spreadsheet. A key concern is the number of users that should be involved in a usability study: five to twelve is considered an acceptable number (Dumas and Redish, 1999), but sometimes it is possible to use fewer when there is a budget and schedule constraints.

Experimental design is to determine which participants to use for which conditions in an experiment. The experiencing of participating in one condition will affect the performance of those participants if asked to participate in another condition

To guide my evaluation, I pose several specific questions to university students:

- “Do you think Imperfectly Fresh could become a part of your everyday life?”
- “How intuitive is the process of adding food items?”
- “Do you feel motivated to share excess food after using this app?”
- “Which features do you find most useful, and what improvements could increase your engagement?”
- “Does the overall design inspire trust and encourage sustainable behaviour?”
- “Do you think if you used this application in your daily life would it be beneficial for you?”

Evaluation Methods

To comprehensively assess Imperfectly Fresh, I plan to employ a combination of controlled usability testing and user satisfaction surveys. Each method will provide different insights:

1. Controlled Usability Testing:

I will conduct testing sessions in a lab environment with 5 participants primarily university students over the age of 18 are asked to perform predefined tasks on an iPhone, such as:

- a. Adding a new food item with its expiration date.
- b. Navigating to the pantry.
- c. Sharing excess food via the app.

During these sessions, I will record quantitative data such as the time taken to complete each task and the number of errors made. I will also observe their interactions. Post-test, I will use interviews and questionnaires to gather qualitative feedback regarding ease of use and overall satisfaction.

2. User Satisfaction Surveys and Interviews:

After using the app in both controlled, I will administer surveys and conduct interviews with participants. These tools will help me gauge overall satisfaction and collect suggestions for improvement. Key survey questions will include:

- d. “How likely are you to recommend Imperfectly Fresh to a friend?”
- e. “Which feature did you find most valuable, and why?”
- f. “What challenges did you encounter while using the app?”
- g. “Do you feel the app’s design motivates you to reduce food waste?”

By combining these methods, I can triangulate data from multiple sources to get a well-rounded understanding of the app’s effectiveness.

Methodology and Participant Engagement

To gather meaningful insights, I invited five university students to use the app and then participate in structured one-on-one interviews. I chose 5 for the evaluation as Nielsons work suggests that testing with five users can uncover most usability issues (Nielson, 2000). Each student used Imperfectly Fresh over a short period and explored its main features without my direct input, allowing for more authentic engagement.

Key Findings

- Most participants found the manual food input straightforward, though two users mentioned confusion around where expired food items go.
- The pantry food categorisation helped users prioritise what to use, but a more visible legend was requested.
- The VisonKit scanner worked well, though misread labels, especially on crumpled or reflective packaging.

Gamification

- All participants responded positively to the tier system, noting that the visual icons made them feel a sense of progression and motivation.
- Students preferred the positive reinforcement approach over any guilt-driven tactics (e.g., Grumpy bin-style design), appreciating the encouraging tone.
- Participants suggested adding motivational quotes or sustainability facts after achieving a tier.

Suggestions obtained from interviews

- Improve visual distinction between shared and personal pantry items
- Add more educational tips to support learning about food storage
- Consider a “fridge view” visual layout to help users picture their inventory

Through structured usability testing and respectful, user-focused interviews, I gathered valuable feedback confirming that Imperfectly Fresh meets its core objectives which is engaging students in food tracking, promoting sustainability, and offering an enjoyable user experience.

Users expressed strong support for the personal growth-oriented rewards system, favouring it over punitive alternatives. The evaluation also revealed areas for technical and visual refinement, offering direction for future iterations.

Overall, this evaluation affirms that Imperfectly Fresh successfully encourages behaviour change while creating a rewarding and educational experience. Ongoing testing with a larger cohort, and enhancements to feature integration and UI fluidity, would further strengthen the app’s effectiveness and impact.

Participant Results Table

Participant	Ease of Use (1–5)	Motivation to Reduce Waste (1–5)	Most Liked Feature	Main Suggestion
Participant 1	5	4	Tier system	Add fridge-style inventory view
Participant 2	4	5	Tier system	Clearer distinction of shared items
Participant 3	4	4	Scanner and visual rewards	Improve scanner accuracy for labels
Participant 4	5	5	Icons for progress	Include educational food storage tips
Participant 5	3	4	Motivational tone and icons	Add motivational quotes on tier achievements

Task Completion Times (Captured with a timer in a controlled setting)

Participant	Add Item (seconds)	Navigate to Pantry (seconds)	Share Item (seconds)	Total Time (seconds)
Participant 1	9	7	10	26
Participant 2	11	10	14	35
Participant 3	15	5	11	31
Participant 4	12	11	13	36
Participant 5	18	12	16	46

Conclusion

This evaluation confirms that Imperfectly Fresh is more than just a functional prototype; it is a promising, motivational tool for promoting food sustainability among students. Through usability testing and user-centred interviews, I gathered feedback that supports the app’s central design and highlights areas for improvement.

The gamified system and clean interface contribute to a sense of person progress and responsibility, which users found rewarding. Most importantly, the app was perceived not just as a utility but as a potential part of user's daily routines an encouraging sign of its capacity to influence sustainable behaviours

Looking ahead, future development of Imperfectly Fresh will prioritize refining its usability, expanding its feature set, and exploring deployment opportunities beyond the university environment. The app holds the potential to serve broader communities and foster environmentally conscious food habits on a wider scale.

Future Refinements for the App:

- **Refine inventory visibility:** Improve clarity between shared and personal pantry items.
- **Introduce educational tips:** Integrate brief, context-aware facts about food storage.
- **Wider Testing:** Conduct evaluations with larger, more diverse student groups to validate long-term effectiveness
- **App Store Readiness:** Prepare the app for potential deployment to the App Store by addressing scalability, data privacy, iCloud synchronising across devices, and performance optimization.

Through continued development and testing, Imperfectly Fresh can grow into a robust tool for reducing food waste and promoting responsible food management habits across campuses.

Conclusion

The result, *Imperfectly Fresh*, successfully integrates food tracking, gamified motivation, and community food sharing into a cohesive, student-friendly iOS application. Through iterative design, user testing, and behavioural theory, the app demonstrates its potential to turn sustainable intention into action—especially by embedding motivational cues like tiered icons and progress rewards.

Feedback from usability testing suggests strong engagement with the app's design, particularly the personal growth-focused rewards system. Students expressed that the positive reinforcement approach—modelled after Duolingo-style gamification—felt encouraging and intuitive, and many reported increased motivation to track and share food responsibly. This supports the broader finding that digital nudges, when paired with emotional and social value, can meaningfully affect daily habits.

While this project achieved its main objectives, limitations included a small test group, limited development time, and platform-specific deployment (iOS only). These constraints open avenues for future iterations, including Android compatibility, expanded food education content, AI-driven expiry forecasting, and enhanced sharing features.

In conclusion, *Imperfectly Fresh* highlights the power of combining behavioural science, user-centred design, and gamification to address real-world issues. By making sustainability interactive, social, and rewarding, this app offers not only a practical tool for reducing food waste but also a scalable model for digital sustainability interventions that resonate with younger generations. *Imperfectly Fresh* represents more than just a coursework submission. It is a demonstration of how interdisciplinary thinking across digital humanities, information technology, design, and psychology can be used to tackle urgent global issues. By empowering students with tools for mindful consumption and collective action, this app contributes to a broader movement toward sustainability and responsibility in our everyday choices.

Looking ahead, there is great potential for deploying *Imperfectly Fresh* on the Apple Store with a few extra I would like to add implementing machine learning for smarter expiry predictions, having more tiers. Furthermore, with more robust evaluation data over time, there is a scope to publish findings on the effectiveness of behavioural gamification in sustainability-focused Apps, building on principles already proven effective in business contexts (Enterprise-Gamification.com, 2003).

Appendix

Imperfectly Fresh Open Day Presentation



Image 1 - Green Theme Indicating Sustainability

Sample Information Sheet (survey)

^A Thank you for considering participating in this research project. The purpose of this document is to explain to you what the work is about and what your participation would involve, to enable you to make an informed choice.

The purpose of this study is ^AWhat features could be implemented in a food expiration tracking app that can promote food sharing amongst third level students, and how can these be implemented to encourage awareness in food waste? to examine the experience of students who commute to university from hometowns outside of the Cork Metropolitan Area. Should you choose to participate, you will be asked to To comprehensively assess Imperfectly Fresh, I plan to employ a combination of controlled usability testing and user satisfaction surveys, which will include items on using Imperfectly Fresh on an iPhone.^A

Participation in this study is completely voluntary. There is no obligation to participate, and should you choose to do so you can refuse to answer specific questions or decide to withdraw from the study prior to completing the survey. All information you provide will be confidential and your anonymity will be protected throughout the study.

^A You maintain the right to withdraw from the study at any stage up to the point of data submission. At this point, your data will be collated with that of other participants and can no longer be retracted.

The anonymous data will be stored on a University College Cork supported cloud storage platform [PLEASE SPECIFY WHICH PLATFORM WILL BE USED AND ENSURE THE SAME DETAILS ARE PROVIDED IN Q30 OF THE SREC APPLICATION FORM].

The data will be stored for minimum of ten years. [UNLESS THERE IS ANOTHER REQUIREMENT FOR YOUR RESEARCH DATA].

[PLEASE REMOVE FROM YOUR INFORMATION SHEET IF THIS DOES NOT PERTAIN TO YOUR PROJECT]: IN CERTAIN CASES, YOU MAY DECIDE TO REQUEST PARTICIPANTS' CONSENT TO STORE ANONYMISED DATA INDEFINITELY IN AN EXPLICITLY SPECIFIED DATA REPOSITORY, AND TO ALLOW THE DATA TO BE REUSED FOR SUBSEQUENT RESEARCH STUDIES. IN THE



CASE OF MORE SPECIFIC DATA REPOSITORIES, WE ENCOURAGE YOU TO SEEK APPROVAL FROM THE EXTERNAL REPOSITORY].

The information you provide may contribute to research publications and/or conference presentations. The data gathered will be presented anonymously in a final year project.

We do not anticipate any negative outcomes from participating in this study [IF YOU DO, YOU MUST SAY SO EXPLICITLY – e.g., WE DO NOT INTEND TO CAUSE ANY DISTRESS TO PARTICIPANTS. SOME OF THE TOPICS BROACHED IN THE SURVEY, HOWEVER, ARE OF A SENSITIVE AND PERSONAL NATURE. SHOULD YOU WISH TO DO SO, YOU CAN CHOOSE NOT TO ANSWER QUESTIONS, OR TO WITHDRAW FROM THE SURVEY]. Should you experience distress arising from participating in the research, the contact details for support services provided below may be of assistance. 116 123, Pieta's helpline at 1800 247 247, or Text 50808.

If you have any queries about this research, you can contact me at 121420536@umail.ucc.ie.
Or Dr Laura Maye l.maye@cs.ucc.ie, +353 21 420 5889.

If you agree to take part in this study, please complete the consent form overleaf.



Sample Research Consent Form

Do you consent to participate in this study?

Yes	<input checked="" type="checkbox"/>
No	<input type="checkbox"/>

Image 2: Sample Consent Evaluation Form

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