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User Experience & Human Centred Design for a blockchain based provenance traceability platform

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Contents

1 Abstract

The study measures the usability of a live prototype of an early stage Blockchain-based food provenance application named FoodPrint. The aim is to see the effect of human centred design principles on the user's engagement with, and the perception of the application.

This study describes a human-centred design approach to designing an early stage blockchain based supply chain web application, which is aimed at improving user engagement at a farmer's market. Design thinking and user experience design frameworks are used to guide the process of researching, analysing, designing, building and testing the prototype. A user interface is designed and deployed to see how the users perceive the value of the web application based user experience design.

With the assistance of Oranjezicht City Farm market management team, the researcher carries out user experience research based on design thinking principles. The purpose is to create the first iteration of supply chain application that provides insight into the provenance of the fresh produce.

The study is on human-centred design principles with a focus on user experience and engagement. User experience and design thinking methodologies form the basis of the study. The study involves surveys and observations that result in two user personas that are used for the design and prototyping of the high fidelity application.

The deliverable for this study is a high fidelity prototype for a fresh produce provenance application that uses blockchain technology. It is accompanied by usability testing focusing on the perceived value and usability of the early stage blockchain-based application

2 Introduction

This study focuses on the creation of an early-stage blockchain based supply chain application for a farmer's market. It uses a prototype to explore principles of human centred design and usability testing. This study falls under what Oulasvirta & Hornbaek (2015) call a conceptual-constructive problem in HCI research.The research type focuses on providing insight on the construction of an interactive artefact to be used for human computer interactions, while making use of methods and principles of HCI. The emphasis is on the ideas and principles it manifests instead of the construction itself (Oulasvirta & Hornbaek, 2015).

This study explores the use of design thinking and user experience design frameworks to design an artefact based on the blockchain technology. With its innovative capacity, the blockchain has characteristics that require special attention when it comes to user interface design.

The value humans extract from technology plays a role in the rate at which the technology is adopted by the mainstream. Blockchain technology is able to offer value within supply chain within the agricultural supply chain for small scale farmers (Kamble, Gunasekaran and Sharma, 2020). The level of use and acceptance is dependent on the ease of use and the value that end user finds in it (Ponce, Polasko and Molina, 2016). The field of human computer interaction (HCI) provides guidance on how emerging technologies can be developed to cater for people's needs.

The study's deliverable is an analysis on the early stage prototype alongside based on the design process and usability testing results. This can be used to improve the future iterations of the web application. The focus on one out of the main challenges faced when it comes to blockchain is possible since this study only covers the first iteration of the fully-fledged blockchain application. The study is part of a long term project to use blockchain technology to create a supply chain platform that offers transparency, security and efficiency amongst small-scale farmers within the Western Cape region.

At the centre of this project is Oranjezicht City Farm (OZCF) market which sources fresh produce from small scale, which are predominantly located within the Western Cape province. These farmers grow their produce using either organic, sustainable or pesticide free methods. Some of the farmers providing the market are grassroots projects active in vulnerable communities.

The farms are located all over the geographical regions of the province. They do not have the capacity to personally attend the market every week and sell their goods. Many of them grow niche products and do not have the capacity to cover the financial burden of travelling into the city to sell their goods themselves. Therefore,

OZCF provides a central point of sale for consumers to access their products. It also allows them to focus on finding other places to supply their produce to.

This study is making use of empirical user experience research that tests the usability of the web application in real world settings, instead of laboratories. The study will not go to the core of theoretical UX research but will instead look at developing User experience design and design thinking as tools for developing usability-optimized blockchain-based applications.

This study aims to increase the knowledge of how human centred design can affect the users' engagement and the usability of a product. Keskinen (2015) argued that grounding practical user experience evaluations in readily available theories or methodology is far from reality. In line with that thinking, this study will evaluate UX of a high fidelity prototype in a real world setting. The study will map out the product development process up until the usability testing as part of the user experience evaluation.

Design thinking approaches are used to carry out user surveys and observation at the market. The insights from the surveys and observations provide insight into the environment at the market and who the users ate. At this point, the design thinking framework intersects with that of user experience design. User experience design focuses on building the solution. The insights from the observations and surveys are used to create personas that inform the end product. The insights are gained from analysing the survey responses using cluster analysis. The persona is created and it provides an aggregated archetype of all the observations in that cluster. Scenarios are created following user personas to create instances of when and how the solution might be used.

The information architecture shows how the various players and data types will interact. It structures the participants who will be making use of the app and the data involved. Farmers and market administrators will both enter static data that will be stored in a static database and dynamic data for the blockchain. The web application will source the data from the various sources and display them to the end user. The information architecture also features the data they will be inputting, the technologies being used and how they all link to one another to reach the end user as website application.

2.1 Study Problem

The majority of the small scale farmers whose products are sold at the OZCF market are limited in resources. They do not have the time or labour resources to attend the farmers' markets themselves and interact with the customers. They depend on

the OZCF market to pass on the brand story, farming practices and fresh produce information onto the customers.

With the onset of the COVID-19 pandemic, there are social distancing measures put in place to limit the spread of the virus. The measures in place include a compulsory face mask and a distance of at least 1.5m between all individuals. As a result, the personnel at the farmer's market are not able to interact with customers as they usually do. This is, however, a blow to a business whose appeal is in their close links to the farmers they source from and the customers they serve.

Based on conversations with the market's director, one of the main aims of the market is to decrease the gap between consumers and their food's origin. Hence part of the study's output is a blockchain-based application that will act as an educational resource on the market's fresh produce and its suppliers. The blockchain based platform will provide the information about the products that the customers would have normally received from the personnel. Users are able to access it while waiting in line to gain access to the market and while perusing the fresh produce on offer.

The final artefact is an early stage iteration of a solution that will connect the multiple stakeholders in the small-scale sustainable farming sector using the decentralised blockchain technology.

According to Laudan (1978) the research problem is defined as the absence or gaps of knowledge in HCI. The study focuses on how design thinking and user experience design principles can be used when designing a blockchain based web application that pertains to food provenance.

The blockchain provides an immutable and decentralised database for the stakeholders in the market's supply chain to share information regarding the fresh produce. This data can be collated and shared with the consumers via a mobile device. This circumnavigates the barriers put in place by the social distancing measures. However, as an emerging technology, blockchain struggled to move from its niche field to the main stream. User interface design has been identified as an important way of increasing user adoption of blockchain applications. One of the main reasons for the lack of blockchain applications in the mainstream is the complicated jargon and technical terms that results in user interface that is too complicated for end-users.

The users will be viewing the application from their mobile device's web browser. There is a high risk of user fatigue due to a complicated user interface and overly advanced technology. The issues become how to keep users engaged with the platform while dealing without lowering the perceived value of the offering.

2.2 Study Goal

The study describes an approach to facilitate the design of an early blockchain based provenance traceability application aimed at improving user engagement using Design Thinking and User Experience design principles. The output is a live web application that is analysed using System Usability Scale usability testing.

The study is carried out at Oranjezicht's City Farm (OZCF) market. It uses design thinking and user experience frameworks to find the main pain points of both the visitors to the market and the farmers' market personnel. From a design thinking point of view, the pain point focused on is the chain of information from the market personnel to the visitors. .

The goal of the study is to explore how the implementation of design thinking and user experience design principles enable the usability of a blockchain-based web application. The formerly in person conversations about the fresh produce's origin are replaced by the application. Harvested produce from the farmers is tokenized and placed in the blockchain. The application will then access the data and display it on its platform the end-user's perusal.

The UX design minimizes the jargon, masks the underlying complexity and simply communicates the data to the customer. This has been highlighted as an issue when it comes to UX design for blockchain as the current platforms are heavy on the technicalities, making it hard for the general public to use. The aforementioned issue can inhibit the adoption of blockchain-based platforms and require more resources to be spent on educating the end-user.

1. How can design thinking be applied to blockchain-based supply chain web applications?
2. How can user experience be applied to blockchain-based supply chain web applications?
3. How does the use of design thinking principles and user experience design affect the usability of a blockchain-based web application?

3 Theory

3.1 Human Centred Design (HCD

Human Centered Design (HCD) is a process of designing that centers around the end-users. The formal definition of HCD offered by ISO 9241-210 is "a systematic approach to interactive system development that focuses specifically on making systems usable (International Organization for Standardization [ISO], 2010)." HCD develops solutions by integrating the human perspective in all the steps of the problem-solving processes. HCD assists practitioners in ensuring that the solution they are creating matches with their user's needs.

In 1955, an American industrial designer, Henry Dreyfuss, presented the text, "Designing for People." He provided methods that UX designers used to understand and design products that meet and exceed user's needs (Dreyfuss, 1955). These are some of the early milestones that lead to the creation of User Experience design.

The official term User Experience was created in 1995 by Don Norman, an electrical engineer and cognitive scientist. It was used to report on his work at Apple Computers. Don Norman wanted to create a term that would encompass all aspects of the person's interactions with a system.

The 1980s were characterized by the rise in personal computing. The 1990s were characterized by the rise of the Web. As these trends converged, designing for and with people in mind became the foundation for the field of human computer interaction (HCI). As more people started using computers, there was a resulting need to optimize and understand them. The 2000s have been characterized by humans being constantly surrounded by technological devices that allow them to discover, connect and learn in any environment (Ferraro & Ugur, 2011). As a result, HCI has given rise to popular terms such as usability and interaction design. People working in these roles focus on understanding and improving the experience of using the devices for people.

The process of designing can be applied to systems, procedures, protocols and customer experiences in physical and virtual spaces. It goes beyond the creation of products (Naiman, 2019) and focuses on the experiences of the client when using the artefacts. Design can then be used as a tool for transforming businesses and their value propositions to clients.

Design principles are applied to computing in order to create software and machines whose behavior is useful and meaningful to the end-user (Denning, 2013). This study follows the same thought process by making use of design principles to create an application that is based on emerging technology, while offering value. It therefore

requires a focus on user experience with the use of new innovative technologies such as blockchain.

According to ISO 9241-210 standard (2010), User Experience (UX) can be explained as, "a person's perceptions and responses that result from the use or anticipated use of a produce system or service (International Organization for Standardization [ISO], 2010)." It can therefore be said to be the emotional connections concerned with any form of Human-Computer Interaction (HCI). The optimization of the user experience therefore is said to play a role in the uptake of an innovative technology.

At the same time, it is important to understand the characteristics and motivations behind potential end user. This assists in ensuring that the interactions, when using the product, are positive. As a result, the use of human centred design approaches, namely, design thinking and UX design, leads to products that are aligned with the users' needs.

3.2 Emerging Technology

Blockchain is a decentralized distributed database that maintains a list of transactions confirmed by participating node. The successful transactions are recorded in a public ledger (Ismail et al, 2019). Satoshi Nakamoto published a white paper which hypothesized a direct peer to peer payment system that was not reliant on a third party such as banks or a financial institution (Nakamoto, 2008).

Nakamoto linked every transaction to the previous ones in a tamper-resistant manner using a public ledger. This solved the problem of double spending. This resulted in the introduction of Bitcoin, a digital currency. The network was able to check if the coin being offered for payment by a user had not been spent yet by looking into the coin's transaction history.

Recently, other fields beyond the finance industry have started making use of blockchain. These fields include, and are not limited to, medical records, digital identities, smart contracts and supply chain (Angelis & Ribeiro da Silva, 2019). The move is stimulated by the blockchain's ability to build in trust into a trust-less system that has no central authority mitigating the risk (Ismail et al, 2019).

The agriculture industry is moving towards digitization. Blockchain offers solutions for on-farm and post-farm gate human technology interaction (Fielke& Bardsley, 2012).Post-farm gate solutions involve the tracking of the produce from the farm through all the processing centers, pack houses, logistic centers, up to the retailers. The main issues with digitization for small scales are fragmented processes, provenance, trust and information invisibility (Bore et al., 2020). The various capabilities of the blockchain can assist in solving the aforementioned issues.

The main drivers for farmers to adopt digitization, specifically for the sake of provenance is availability of cost-effective solutions and the ability to increase competitive advantage (Manos& Manikas, 2010). The key constraints are the inability to manage such systems , lack of coordination between stakeholders and the difficulty of product and lack of funds to invest in such schemes (Canavari et al., 2010).

Traceability is introduced on farms more often due to demands by customers and consumers instead of them being initialised by farmers (Manos& Manikas, 2010). Retailers who want to receive premium prices from the consumers require a higher trust in the fresh produce and its provenance. So for supermarkets and farmers' markets that buy from farmers, it is important to communicate the right amount of information in a way that does not generate confusion to the consumer about the real meaning of traceability (Canavari et al., 2010).

User interface design has been identified as an important way of increasing user adoption of blockchain applications in a way that's attractive to the end-users. When dealing with emerging technology (such as blockchain), user-centric methods are limited with many developers being in favor of the technology-centric methods. HCD is limited by users' inability to envision futures involving emerging technologies as their thinking is based on the capabilities and limitations of existing technologies (Morris et al., 2014). However, technology-centric methods, while they fail to meet user's needs, perform well when it comes to creating new gadgets or systems (Velloso et al, 2018).

Holmquist (2012) divided the process designing innovative application into inquiry led and or invention led. The inquiry led process favors the use of HCD processes to discover the needs and wants of the users. This is achieved using qualitative and quantitative methods. The tech led processes initially focus on the opportunities provided by the emerging technology to expand the design space. The process takes place when they are not yet commercially available to the larger market and are conducted with prototypes. As a result, a balance needs to be met that makes use of both technology-centric and user-centric methods when designing with emerging technologies.

The main pain points associated with blockchain applications when it comes user interfaces are industry jargon, system feedback when latency is high and user authentication. Blockchain technology is not easy to understand intuitively. As a result, its main user base has been concentrated on a small population that is knowledgeable about it. For the technology to enter the mainstream, and its potential to be fully realized, the way the application's front-end is designed needs to be adapted to its needs.

User experience design, focusing on user engagement, offer a possibility to smooth

out these issues. The perceived value of the application from the user's point of view is focused on instead of the complexity of the underlying technology.

3.3 Small Scale Agriculture Value Chain

More than 60% of the South African population now resides in the urban areas. This growth has been accompanied by an increase in the middle class who have a lot more disposable income per capita (Louw et al., 2008). In line with international trends, new consumption patterns have emerged, and this points to the increase in demand for high quality and diverse food offerings. Consumers are willing to go premium for sustainably grown, pesticide free fresh produce. This offers an opportunity for small scale farmers to increase their profit margins.

The smaller players have been pushed out due to the vertical integration and consolidation of the sector. Supermarkets have changed their procurement policies and now prefer to procure fresh produce from a limited number of preferred suppliers (Louw et al., 2008). As a result smaller players require alternative ways to reach this growing population of customers.

Farmer's markets allow producers to market food directly to consumers thus circumventing the multiple middle men involved in the complex fresh produce supply chain. The consumers are therefore able to find out as much information as they need to know about the products on sale. Farmer's markets are characterized by the seller being the person responsible for the growing, rearing and production of the goods. This puts the consumers closer to how their food has been produced and provides increasing awareness of seasonality in food production. (Trobe, 2001). Markets are recognised as a tool that incorporates values of environmental sustainability and equity into farmer's agricultural practise and marketing (Fielke, Taylor& Jakku, 2020). Products that communicate this effectively attract premium prices.

However, small scale farmers in South Africa are limited in resources. Small scale farmers tend are limited in the distance they can travel to markets (Matsane& Oyekale, 2014). They are not able to provide the labour and transportation involved in the participating in a weekend farmer's market in the city. This is because the majority of smallholder farmers are situated out of the city and the urban farming initiatives are situated in informal settlements, away from the affluent neighbourhoods where the markets are held and the customers reside. They also face the operational risk of sending their available workforce to a specific market and then missing out on all the markets available during the same time. The produce that they would have not been able to sell would result in a financial loss.

Oranjezict City farm (OZCF) market is farmer's market that sources its supplies

from a myriad of small scale producers around the Western Cape. It offers farmers a guaranteed amount of income as they buy the produce from the farmers and take up the risk of selling it to consumers. This allows farmers to explore other avenues to sell the produce that OZCF does not buy.

However, they lose out on the ability to market themselves to the consumers and the consumers are not able to directly interact with the producers of the products they are buying. Many of their patrons are attracted by the availability or organic and pesticide fee fresh produce. Market administrators and employees therefore spend part of their time at the market explaining to the inquisitive customers the source of the produce and the growing conditions. This helps make up for the lack of the farmers' presence at the market and still offer customers proximity to the source of their produce.

With the COVID-19 pandemic, the ability for the conversations to take place has been decreased. The World Health Organisation (2019) advises businesses to take steps in order to minimise the spread of the coronavirus. In response, OZCF market has social distancing measures in place. They require 1.5m distance to be always kept between individuals and for everyone present at the market to wear a face mask. The measures have also resulted in, at times, people queuing in order to enter the market, as it has had to lower their its capacity.

This provides an opportunity for technology to bridge the gap between the market and the patrons. Blockchain is especially suited for this as it allows the farmers and the market to independently load information onto the blockchain. The information can not be tampered with and is available on a distributed ledger. The FoodPrint application has an API that can extract the data from blockchain in order to display it for patrons' perusal. However, besides simply showing the data, the application has to meet user expectations and provide an enjoyable user experience.

4 Frameworks

The study's execution is focused on the application's pre-development stage which predominantly makes use of design thinking principles. As seen in Table 1, UX design principles only come into play halfway through the analysis. Even though design thinking and user experience overlap, the user experience components are predominantly referenced for the building of the product. It should be noted that the core functionalities and specifications built into the product are informed by work done during design thinking portion.

Phases of Research	Design Thinking	UX Design	Execution Steps
Research	Empathize		1 - Survey 2 - Observations
Analyze	Define		3 - User Persona
	Ideate	1 - Understand core functionalities 2 - Define system and the apparatus 3 - Ideate through braining storming and looking at related work	4 - Information Architecture
Build	Prototype	4 - Design and build the UI and interaction events	6 - Prototype
Test - Usability Testing			

Table 1: The phases of the study's research show in parallel with the steps present in design thinking and user experience frameworks. At the end is the steps taken in executing the study lined up with phase/step of the research/framework.

4.1 Design Thinking

The study uses design thinking principles during the pre-development phase of the application. Design thinking provides a template on interacting with stakeholders. This is carried out during the surveys and observations of the defined step output of the user personas that are aggregated profiles of the market attendees. Their characteristics and motivations are aligned with the functionalities provided by the application. In this study, the model of integration is known as unified project model. Dobrigkeit's & de Paula's (2019) work on the design thinking in software engineering defines this as the initial phase with a large overlap into the development's team work.

Brown & Wyatt (2009) discuss how conventional research leads to incremental changes in systems, and it offers design thinking as a tool for leapfrogging into innovation. By moving from predominantly using face to face interaction and social media to creating the FoodPrint application, I argue that design thinking is instrumental in ensuring that the resultant solution goes beyond what is currently being done while meeting the users' needs.

Design thinking was proposed by members IDEO, David Kelley and Tim Brown, alongside Roger Martin in the 1990's. Brown (2008) defines Design Thinking as, "a

discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity." In line with Design Thinking, HCD processes create design artefacts that address real and not imaginary user needs and then test those artefacts with real users (Gibbons, 2016).

Designing thinking based on Stanford d.School (2010) is broken up into five distinct steps. The process is not linear and can back and forth between a pair of stages when there is iterative design taking place. The five steps are as follows:

1. **Empathize** - The brief is the starting point where the objectives, constraints and benchmarks are set out. Afterwards practitioners go out and observe the people they are building for in the environment they will be using it in. By embedding themselves in the lives of the end-users, they better understand their needs and motivations.
2. **Define** - Coming back from the field, practitioners synthesise what they saw and heard that can lead to opportunities for innovation.
3. **Ideate** - This is where the brainstorming takes place. Practitioners work through multiple ideas until it is distilled to best one or ones. The best ideas and insights are turned into an actionable plan.
4. **Prototype** - This marks the implementation phase where the ideas are turned into products. By building the product, practitioners uncover unforeseen implementation challenges and have to rework a few ideas. It is possible to briefly jump back into the ideate stage so as to come up with solutions for the problem areas.
5. **Test** - At this stage the prototype is tested for real world implementation. Continuous changes are made until it reaches the final stage.

4.2 Alternatives to Design Thinking

Denning (2013) asserted that design and innovation were related but not the same. Innovation focuses on getting end-users to adopt a new technology or practice often organized around an artifact or process. As a result, design thinking offers more value in the ideation phase instead of the adoption (implementation) phase. Radical innovations only take place a few times per decade, while small incremental innovations smooth out frictions in the existing product-delivery offer more frequent gains (Norman, 2010).

Kembler's (2009) design thinking framework focuses on the user's characteristics and the usability of the resulting product or service. The motivation for humans making

use of technological devices is the desire to fulfill a need and the design is said to be legitimately fulfilled if the need of the user is truly met (Ferraro & Ugur, 2011). Since the design problems come without closed form solutions, the designers do not know what will be designed and how it will create the desired effect.

4.3 User Experience & Usability

Hassenzahl (2008) defined user experience as a, “momentary, primarily evaluative feeling (good-bad) while interacting with a product or service.” User experience is therefore seen as a result of the presentation, interactive behavior and assistive capabilities of the interactive system (Stewart, 2015).

User experience design is a sub-field of the study of HCI. With the increased use of mobile devices by consumers in their everyday life, tailoring the experience to optimize efficiency and ease of use is important to differentiate brands from their competitors. Customer trends are moving towards embedding online experiences within physical spaces. This can be seen in the emergence of mobile apps by coffee franchises and supermarkets, namely, Vidae Cafe and Pick n Pay, respectively. User experience design is the process of creating products that are centered around the user to provide relevant and meaningful experiences.

The U.S. General Services Administration (GSA) Technology Transformation Service defines usability as "the quality of a user’s experience when interacting with products or systems, including websites, software, devices, or applications. Usability is about effectiveness, efficiency and the overall satisfaction of the user." Usability is therefore a measure of the user experience. It has been attributed as one of the most important factors when it comes to consumers’ decision to reject mobile applications.(Hoehle & Venkatesh, 2015). As a result, it’s an important measure to take into account when it comes to user experience. It helps measure the prioritization of the most important aspects of an application and whether the content is effectively represented.

The process of user experience design involves the tasks of creating personas, user journey maps, designing wireframe and building interactive prototypes as well as testing the designs.

The above-mentioned tasks will be covered during the project. For the purpose of this research, the focus will be on the usability and function of the product that will be created. The focus points will be efficiency, ease of use and visual understanding. However, the people working in the user experience space are also concerned with branding and design, alongside usability and function. This assists them in designing how the product is acquired and integrated into the user’s life.

One of the basic claims of experience-driven design is to consider the experience before products' (Hassenzahl 2010, 63). The claim aligns with the philosophy of the Design Thinking method. The first 2 stages of Design Thinking, empathize and define, focuses on the user and their experience. The product comes into play in the last three stages, ideate, prototype and test. Design Thinking was therefore used to guide the methodology of the EX research process. The UX goals are set in the 'define' stage of the research are assessed against the empathy-based approach. The empath-based approach is one of the five UX goal setting approaches outlined by Kaasinen, E. et al. (2015). The five approaches are Brand, Theory, Empathy, Technology and Vision.

The empathy-based approach aligns with design thinking as it focuses on the user and understanding their needs. Wright, Wallace, and McCarthy (2008) mention that designers are required to engage with their users and their culture in order to achieve adequate experience-centered design as they would gain insights on how the users perceived the technology.

4.4 Usability Testing

The study tests 5 participants using System Usability Scale (SUS) testing, remotely. The participants access the web application from their mobile devices. From there, they follow the prompts and tasks given to them beforehand. After finishing all the tasks and exploring the web application, they are redirected to a final questionnaire that asks about their overall experience, their likelihood of using the application again and extra questions regarding information provided on the application.

Un-moderated testing is when the participant carries a prearranged set of tasks within the application. While they are doing so, their features and the amount of time they take to complete tasks are recorded. Usually, the moderated testing happens in a lab environment with a moderator and observer present with the participant. However, due to the COVID-19 pandemic, remote field testing is the most plausible. Differences in mobile devices meant that some devices could be recorded whilst others could not.

Heuristic evaluations take place when UI experts are presented with a user interface so that they can evaluate them for usability problems present. The task is reliant on heavy pattern recognition and experience (Fernandez, Deja & Samson, 2018). A previous study found that non-UI experts were able to heuristically rate a prototype in a manner that predicted the lab performance (Desurvire, Lawrence & Atwood, 1991). Aggregated evaluations from multiple individuals perform better than individual levels of evaluation (Nielsen & Molich, 1990). Therefore it is better to have multiple individuals evaluating the user interface and supplementing the heuristic

method with other engineering methods. However, this requires resources beyond the scope of the study.

Another method is the System Usability Scale (SUS). The SUS is a mixed tone questionnaire where alternating questions have either a positive tone or a negative tone. It focuses on two main factors, namely; usability and learning (Lewis & Sauro, 2017). Two out of the ten questions of the questionnaire accounted for the learning factor. The remainder accounted for the usability factor. A study by Peres, Pham, & Pillips (2013) found that there was a correlation between a user's performance on usability task completion and the corresponding SUS score. The likert scale is used to calculate the sus score. It is a satisfaction scale that ranges from one extreme attitude to the other. The SUS usability method is therefore a reliable, quick and cost-effective analysis of usability. It is therefore more appropriate for expedited projects that are constrained in terms of time such as this study.

5 Execution

The goal of the study is to examine the effect of user interface design on the user engagement and experience. The study is on human centred design principles with a focus on user experience and user engagement.

The methods chosen align with design thinking and user experience design principles. They help answer the questions on how design and user thinking different. It also answers the question on how both principles can be applied to the design of the blockchain-based application.

Observations, surveys, user personas and prototyping are all part of the process of designing the user interface for the provenance application. The testing of the prototype serves to answer the question of what is the perceived value of a blockchain based application built user human-centred principles.

5.1 Market Visits

The researcher attended the market for five weekends. The market personnel and customers were observed for their interaction patterns. The point of interest included, the patrons' behaviour at the fresh produce stand, the conversations between patrons and market personnel, the technologies being used at the market and the variations of patrons throughout the market days.

The researcher also visited the market the day before it opened for weekend trading. The processes taking place are recorded. This assists in understanding the work that is done up till the moment the customers come into the market. Just before the country went into lock down due to the COVID-19 pandemic, the researcher visited the market again to find out how they will be adapting to the lock down conditions.

The resultant solution is supposed to complement the visit to the market for users. It follows that the onsite research is to provide insight into the touch points between the market and the customers. Throughout the study, the researcher keeps track of the conversation with stakeholders at the market. The qualitative helps inform on quantitative analysis. It provides contextual information. This activity is following the empathize stage of design thinking.

5.2 Similar Projects

Similar applications that are also focused on food provenance using blockchain technology were also researched. The focus is on finding trends and similarities with the FoodPrint application for OZCF market. The aim is to find the main themes

amongst them and decide on the best practices to implement in the study. User Interfaces are critical in the technology adoption process as they affect the end-user's perception of the technology (Ozen Seneler, Basoglu and Daim, 2010). In turn, UX design is dependent on the user's perception for the perceived usefulness and ease of use. Furthermore, a study by Ponce, Polasko and Molina (2016) showed the how the perception of end-users was affected by their confidence in the technology being implemented. As a result, projects chosen are analyzed in terms of goals, user interface and technology stack. They should also should reflect the use of blockchain technology or supply chain transparency. This assists in the designing application for this study

5.3 Survey

Survey methodology provides a simple and fast way to access a population in an environment with a limited resource (Pagano, Dunbar and Stanworth, 2020). The survey is designed to find who the customers are and how they relate to the market. It is disseminated online using the social media channels of the market. Both Facebook and Instagram are used to advertise the survey. The survey is only analysed after it has been active for a week. Participants are informed beforehand that the survey is voluntary.

Using a survey as part of the research methodology poses a limitation in that there is a limit to the amount time respondents spend completing the survey against the possibility of their obtaining benefit from completing the survey (Pagano, Dunbar and Stanworth, 2020). It has been considered that the participant will be accessing the survey by leaving another application where they might have been carrying out a different task. The survey is limited to 10 questions in order to minimize survey fatigue.

Survey questions are to be based on the characteristics of the sample population and considers the background of the intended audience (Pagano, Dunbar and Stanworth, 2020). The insights into audience and sample population is provided by the market manager who is familiar with the patrons of the market. This is in line with Design Thinking principles' encouragement of the participation of stakeholders in design process which includes the survey design in this study. The questions for the survey are as follows:

1. In which age range are you?
2. How often do you shop at the market?
3. What are the three most important factors when choosing fresh produce?

4. Do you come to the market with a shopping list?
5. How many people are in your household?
6. How much do you spend, on average, at the market?
7. Do you use Snapscan?
8. Which phone operating system do you use?
9. On which social media platforms do you follow OZCF?
10. Would you like to know more about where OZCF sources their produce from?

The responses to the questions are a mixture of a categorical choice, text response and numerical value. For the first two questions, the choice of responses are in the form of a range. This has been agreed upon with the market manager. They are more interested in the spectrum than a specific number, as the age characteristics can be explained within an age range and the visits to the market can be irregular and usually range from month to month. Questions 5, 9, and 11 have binary response options of yes or no.

The survey responses are tabulated into a dataset. The dataset is analyzed using cluster analysis. Cluster analysis aims to address the heterogeneity in each data subset which makes it common tool to develop empirical groupings of people and characteristics that share certain characteristics (Nan Tu et al., 2010). Cluster analysis looks at the data to ensure that respondents that are close to each other are grouped together and those dissimilar are grouped apart. Hierarchical analysis is used to cross validate the results. The process is carried out using cluster analysis as they are too many variables to be able to make divisions manually. Within each cluster, the qualitative responses for survey questions are analysed to find the prominent patterns.

The algorithms require the number of clusters to be determined beforehand. The aim of the survey analysis is to get three distinct clusters and create user personas out of the two dominant clusters.

The transformed data is clustered using the PAM (partitioning around medoids). The agglomerative hierarchical clustering algorithm is used to cross-validate the results. The Manhattan distance is used for the PAM algorithm. Manhattan distance measures the absolute value distance instead of the squared error distance as is done for Euclidean distance. For high dimensional vectors, Manhattan is preferred over Euclidean. Manhattan metric places less emphasis on outliers. It aims to reduce all errors equally as the gradient has constant magnitude.

The hierarchical clustering algorithm makes use of the Gower distance for the dissimilarity matrix and Ward's method for the linkages. Gower Distance is a metric used to calculate the distance between two data points whose parameters have a mix of categorical and numerical values. Ward's method defines the distance between two clusters, by the amount the sum of squares will increase when they are merged. The distance matrix from Gower distance calculation was used to carry out hierarchical clustering using Ward's method.

5.4 Persona

After the clustering analysis, the two qualitative responses are analyzed to extract the main thoughts and themes from the customers. The responses from the customers from each cluster are analyzed separately.

The clusters from the survey analysis are used to create the personas. Therefore, the persona is an aggregated profile of all the participants in the cluster. The prominent patterns in each cluster are used to give characteristics to the user persona. The user personas are also informed by the insights from the observations and interviews with stakeholders.

5.5 Information Architecture

Based on the insights from the survey, observations and discussions with the market personnel, I map out the current system at the market. I then list the data requirements and sources. All the information is classified as either static or dynamic. Dynamic information changes every week, while static information hardly changes over time.

I establish a database design for the system based on the information architecture. The information architecture denotes the structure of information within a product. Its purpose is to organize information in a way that meets the user's needs effectively. The way the elements are organised is to be logical and intuitive for the user.

Based on the information architecture, the user journey within the product is laid. The researcher goes back and forth between the information and architecture and the user journey as they inform on each other. At the same time, the researcher checks whether the user journey happens in the same way for both user personas and highlight issues they might face.

The user journey depicts how the user would interact with the product. It is not concerned with functionality and maps out the different stages of interaction. On the other hand, the user flow is more specific. It depicts a specific path the user follows within a product.

User flows define the specific route that a user might take within a class in order to achieve a goal. Information architecture assists in making sure that the result is easily discoverable, while decreasing cognitive load. After deciding the data required, the next step is the user flow which is based on the user journey.

The researcher moves on to designing the wireframe for the prototype. The wireframes follow from the user flow. They are low fidelity designs on the details present on the screen at each step of the user flow. Afterwards, a mid-fidelity prototype is then designed. It includes the expected functionality of the application.

5.6 Prototype

There are two iterations of the live version prototype. The initial design is tested on the market's customers. It is a field test that takes place at the market. The user uses their own. It is made available to the customers and the behaviours of the customers is analyzed. A list of findings is drawn up and scrutinized. Applicable changes are made to the design for the final high fidelity prototype.

The high fidelity prototype is then built using React Javascript library to create a single page application. It is a web page that mimics a native application. It is faster and more responsive. The application is built to be optimized for the mobile experience. Market customers are expected to access the web application while at the market. They are more likely to do this on their mobile phones.

5.7 Usability Testing

The live application is tested using both System Usability Scale usability tests. Due to the pandemic, the testing is done remotely by the customer on their mobile phones.

An email tells the test participants the steps of the study. They carry out the tasks before filling out a survey on the experience. The questions are both quantitative and qualitative. The first ten question on the survey are from System Usability Scale whilst the remainder are application-specific.

The responses are analyzed and the application is evaluated based on the results. The first 10 questions are used to calculate the SUS score using the likert scale method. Every odd numbered question has it's 1 subtracted from it's response whilst every even number question is subtracted from 5. The sum of the calculates per respondent is multiplied by 2.5 to get the respective SUS. The maximum SUS score possible is 100.

6 Results

The goal of the study is to examine the effect of user interface design on the user engagement and experience. The study is on human centred design principles with a focus on user experience and user engagement.

The methods chosen align with design thinking and user experience design principles. Design thinking focuses on trying to understand the patrons at the market and user experience design guides the execution of the product build. It also encompasses the creation of a product that is aligned to who the perceived user is. The testing of the prototype serves to answer the question of what is the perceived value of a blockchain based application built user human-centred principles

6.1 Market Visits

Prior to the survey, the patrons at the market were observed for three consecutive Saturdays. It was noted that majority of the customers, who come for the fresh produce, arrive in early in the morning up till noon. They bring their own reusable bags and baskets. For those who do not have, they make use of the boxes available. Other farmer's markets also make use of their boxes to pack the customer's goods. Those with young children made use of prams to store their produce.

6.1.1 Patron Behaviour Observations

The patrons use SnapScan on their phones to pay. However some opted for cash or to swipe their bank cards. The other major use of phones is to take photos at the market to post them for social media. The people who attend the market at a more leisurely pace, often taking photos tend to arrive later in the day, thus missing the morning rush for fresh vegetables by the focused grocery buyers.

Patrons also refer to social media influencers when discussing which fresh produce to buy. It was also evident when popular fresh produce was unavailable, as the market employees consistently got requests for them. At times, the market personnel find it difficult to keep track of what is still available and what has been sold out due to the large variation of fresh produce available. The issue is also compounded by the periodic rush of patrons which would lead to some products selling out instantaneously.

There are instances where fresh produce that is not normally sold by big supermarkets was available at the market. Patrons inquire from the personnel on how to prepare the specific produce. Based on the feedback, they will choose whether to buy it. There is also a segment of patrons who stay away from fresh produce they are not familiar with and do not inquire about it.

There is evidence of patrons viewing the posts from the market on social media before arriving at the market. They will specifically ask for that produce, and discuss the benefits and characteristics that had been mentioned. Fresh produce featured on the social media pages also sell out frequently.

6.1.2 Produce Drop Off Day Observations

Two visits took place on a Friday, the day before the market. The visits provided insight on the process undertaken to get the fresh produce to the market. It is on this day that many suppliers deliver their produce to the market. Every week market manager comes up with a list of vegetables and fruits that will be ordered for the market. She then contacts the farmers to hear what vegetables that they have. They are certain vegetables that she sources from multiple farmers. Sometimes a single farmer will provide multiple types of produce.

The process is long and iterative as the final orders are based on what the farmers have available and what the market is selling. There is the added complexity of the market aiming to support as many of the local sustainable farmers as possible. As a result, some of the more popular vegetables such as spinach are sourced from multiple farmers instead of a single supplier.

6.1.3 Market Conditions

The manager highlighted education as an important focus of the market. Besides the fresh produce tent, the market also has a food court, a bar and artisanal businesses present. This attracts people who do not normally attend the market to buy fresh produce. The market wants to use the opportunity to educate them about sustainable farming and the benefits of buying local.

The market also wants to extend their education into the growing conditions of the crops. They showed frustration on the lack of understanding between organic, sustainable and conventionally grown crops. They want the patrons to have a better understanding of the work done by farmers and the alternatives to organically certified crops which require a rigorous and expensive process. Many of the farmers that the market sources from makes use of the Participatory Guarantee System. Participatory Guarantee Systems (PGS) are locally focused quality assurance systems. They certify producers based on active participation of stakeholders and are built on a foundation of trust, social networks and knowledge exchange (IFOAM, 2008).

As a result of the pandemic, the market has put in place social distancing measures. Patrons are always required to wear face coverings. All individuals are to keep at least 1.5 metres away from each other. There are also limitations on the amount of

people who can be in the market at a time. The interactions that had been witnessed weeks prior are subdued due to the barriers.

Patrons at the market are already using technology in conjunction with market activities. These activities included paying for their groceries, finding out which special fresh produce was featured and sharing images of themselves at the market on social media. The level of access to mobile devices is facilitative for the introduction of an application that extends on their current experience at the market. It is argued that physical interaction can be enhanced using by the online experience.

The farmers who were present the market also gave some insights. They are interested in finding new ways to interact with the end consumer of their produce. For many of these farmers, growing their produce is a passion. They want to share the story behind their establishments and also increase their presence virtually. Alongside sharing their stories with the customers, they are interested in the application helping them keep track of their farming cycle and the invoicing process as they are currently using manual systems. Both the farmers and the market manager mention that an integration with the existing Participatory Guarantee System will help them when it comes to tracing the certification of the inventory sent by the farmer and present at the market.

6.2 Similar Work

There is a trend taking place where consumers are interested in understanding the provenance of their food. The motivation tends to be either for health purposes or sustainability practises. Due to the lack of transparency there are unfair practices that take place in the processing of sourcing goods. In response to this IBM built Food Trust. It is built on the IBM blockchain to help enable a more efficient supply chain on a global scale. It's farmer connect app aims to bridge the gap between consumers and people who farm their coffee by documenting the journey from the farm to the cup.

6.2.1 IBM: Farmer Connect

IBM (2018) believes that the blockchain enables full transparency by digitizing transaction records and storing them in a decentralized and immutable manner, eliminating opportunity for fraud across the food chain. It also believes in allowing stakeholders to automatically digitize and easily share audits, certificates, and other records proving that they utilize and promote sustainable and ethical practices.

This is an attractive solution for OZCF since the consumers, farmers and the market are varying distances from each other. Each participant is can enter their data. The

consumer will be able to view the data knowing that the immutable thus eliminates fraud in reporting practices on whether the food is grown organically or conventionally. The market's customer will then be able to access data on their fresh produce. This also takes away pressure from the market personnel who are not able to keep track of information on all the fresh produce.

IBM's Farmer Connect's vision is to "humanize consumption through technology" (Farmer Connect, 2020). The vision is in line with OZCF market's manager aim to put faces behind the produce they sell at their market. Farmers are able to connect to the supply chain through their platform, while consumers are able to view the coffee's provenance.

Farmer Connect aims to provide efficiency is a space that is fragmented, global and complex. On the other hand, OZCF is smaller scale but it is dealing with a complex system that has many players whether its numerous farmers providing niche produce or various team members who work at the market. Farmer Connect has a consumer facing application that pulls information directly from the blockchain in a standardized fashion. It connects all the stakeholders using an interactive map to tell the story in a simple and scalable way. The mobile application can be accessed by scanning a QR code. This is a method that works well at the OZCF market as well since users already use QR codes to pay for their produce and it is contact-less as well.

6.2.2 Abalobi

Abalobi is a social enterprise based in Cape Town. They employ technology to alter the dynamics of supply chain in local small-scale Fisheries (Bonthuys, 2020). It uses technology in its work on poverty alleviation in the small-scale fisheries by promoting traceable seafood that is ecologically responsible and socially fair (Raemaekers, 2019).

Abalobi is using modern technology to develop sophisticated monitoring systems for the small scale fisheries. They currently have a set apps that are used by all participants on their supply chain to increase efficiency, transparency and the economic participation of small-scale fisheries. Using their mobile suite, Abalobi enables small scale fisheries to be integrated into information and resource networks. The work they do aligns with that of the OZCF market in that some of the farmers that provide the fresh produce for the market are farming initiatives from townships such as Phillipi. The market manager stipulated that the market's aim is to expose small scale farmers to more consumers so that they can thrive financially. However, due to financial and time limitations the farmers are not able to come to the market every weekend to interact with their customers. As a result the market is always finding

ways to share their stories using social media.

Abalobi has created a consumer facing application that functions as a marketplace. The application is currently in the concept phase. One of its main features is providing Co-op faceability. The feature shares the story behind the fish, while promoting fair trade practices. It will provide a public profile for fisheries based on a set of criteria. This is in line with the FoodPrint application is aiming to do something similar for small scale agricultural space. This study's output is the first iteration in a move to create a more connected sustainable agricultural network amongst small-scale farmers and the consumers. To make up for the distance between customers and farmers, an online profile will offer exposure and a means of connection. It will also act as a form of education for its customers.

IBM offers insight on how complex global food supply chain systems are making use of blockchain to offer transparency. There are many players who are geographically separated. Blockchain technology offers a way to track the journey of coffee using an immutable database that offers transparency and creates trust.With Abalobi, a local solution is providing access to market for small-scale fisheries, while promoting sustainable practices. They are showing how technology can be used to manage multiple small scale producers in an efficient way that allows them to participate in the economy. They are going a step further by building a marketplace that provides online visibility for the small-scale co-ops, while educating consumers of the intricacies of sustainable fishing.

OZCF market is a business that sources their produce from multiple small-scale farmers who grow both popular and niche crops. They have become an important entry to market for the small scale farmers and would like to take the extra step to bring them closer to their end-consumers. At the same time they are educating the customers on the nuances of sustainable and organic farming. The adoption of blockchain technology will allow them to collate trusted information from the multiple sources. The existing geographical barriers and onset of the COVID-19 pandemic can be dealt with by providing a decentralised way to collect the data and share it with their customers.

It is therefore important that they are able to capture their customer's attention, while attempting to share this information. The IBM coffee tracing application will be for a specific package bought and the same applies for Abalobi. With Abalobi, customers receive a QR code with their invoice so that they can view the entire story behind the fish. Where the OZCF market differs is that they are showing the information regarding the produce before payment. They are going a step further in trying to entice customers into perhaps trying new products, while learning about how it came to be. As a result, it important to focus on the interaction events that

take place during a transition to ensure that the application is fully utilised.

6.3 Survey

The final number of responses from the survey is 72. The survey was disseminated via Instagram and Facebook, with the majority of the responses coming from Facebook. The majority of the age ranges are from 36-50 and 51-65 intervals. The least number of respondents are from the 65+ age range. Only 6 respondents opted not to learn more about where the market's fresh produce comes from.

People over the age of 50 face an increasingly highly chance of hospitalization from the coronavirus (Mahase, 2020). As a result, they are encouraged to only leave their residences for essential purchases. This puts the majority of those who responded more likely to minimize their physical engagement with others when attending the market.

Age Range	Tally	Percentage
18-25	12	16.7%
26-25	11	15.3%
36-50	25	34.7%
51-65	19	26.4%
65+5	5	6.9%

Table 2: Age range distribution amongst the respondents.

The frequency of visits at the market varies amongst respondents. Within each age group, there are varying frequencies of visits. Overall, the majority of respondents visit the market 1-2 times per month. As the frequency increases, the number of respondents decreases. This can be explained by the market's proximity to some of the most popular tourist attractions. As a result, their patrons are a mixture of consistent and shoppers, and those who visit occasionally.

Frequency	Tally	Percentage
1-2 times	47	65.3%
3-4 times	18	25%
5+ times	7	9.7%

Table 3: The frequency of visits by the respondents.

Two of the questions in the survey look into the behaviour of respondents at the market. The majority of the respondents (50) attend the market without a shopping

list. Snapscan is one of the payment methods offered at the market. It is used by 75% of the respondents. All the respondents have access to a personal mobile device, with a third of the respondents using Android instead of Apple's mobile operating system.

Most of respondents follow the market's social media on Instagram and Facebook. The least number of respondents follow the market on Twitter. Just over a quarter of the respondents are also subscribed to the market's newsletter.

Social Media Platforms	Tally	Percentage
Instagram	48	66.7%
Facebook	61	84.7%
Twitter	8	11.1%
Newsletter	19	26.4%

Table 4: A breakdown of the social media platforms that respondents use to connect with the market

As can be seen in Table 5, the cross-validation results in two clusters. The respondents in each group are analysed which includes analysing the qualitative responses.

	Cluster 1	Cluster 2	Cluster 3
Cluster 1	**10**	1	1
Cluster 2	7	**18**	12
Cluster 3	0	17	**0**

Table 5: Cluster cross-validation. The hierarchical results are along the column, while the PAM results are along the rows.

The proposed application is focused specifically on the fresh produce tent. As a result, it is important to see how the respondent experiences of the fresh produce tent compares to the market as a whole. After analyzing each cluster, it is possible to create fictional personas that are reality-based. The responses from the customers from each cluster are analyzed separately.

The first qualitative question focuses on the market as a whole including other traders. The second qualitative question focuses specifically on the fresh produce tent. The rest of the quantitative and binary questions are aggregated from the cluster summaries. The parameters that are binary or quantitative are aggregated and tabulated in Table 6.

Parameter	Cluster 1	Cluster 2
Age Range	60% of respondents are within 51-65	61% of respondents are 36-50 age range
Shopping List	70% Yes	77.8% No
Snapscan	90% Yes	61% No
Phone OS	60% Android	55.6% Android
Instagram	60% Yes	94% Yes
Newsletter	100% Yes	100% Yes
Facebook	90% Yes	83% Yes
Twitter	20% Yes	16.7% Yes
Average HH Size	Avg = 2.4, median = 2	Avg = 2.2, median = 2
Average Spend	R450	R406
Visits	Equally range throughout	90% come 1-2 times a month

Table 6: The table shows the resultant clusters and their characteristics with regards to the 11 parameters that were covered in the survey.

6.4 Personas Created

Cluster 1's qualitative responses predominantly named freshness, produce, variety and local supply as their favorite aspect of the market as a whole. The three most important factors when choosing fresh produce are fresh, organic and there is a tie when it comes to flavor price, locality, and seasonality.

Cluster 2's qualitative responses also named freshness as a favorite aspect of the market. The other two favorites are atmosphere and the organic factor. When it comes to fresh produce, what is most important to them is freshness, packaging, seasonality, and locality. There is also a mention of quantity control which ties in with the lack of packaging.

The two user personas are based on the quantitative and qualitative responses present in each cluster. They are tied in together with the observations made at the market to give a well-rounded view of the personas.

Cluster 1

Name:: Mary-Anne Fulton
Age: 64
Location: Gardens
Status: Married
Job: Performing Arts lecturer
Education: Postgraduate level
Interests: Gardening, Pottery, Traveling
Social Media: Predominantly active on Facebook
Bio:

Mary-Anne is a lecturer nearing retirement. Both her kids have left the house and she lives with her husband and their two Huskies, Bruno and Caesar. In her free time, she can be found digging around in her garden or paging through lifestyle magazines.
Prior to the weekend, she checks the pantry's inventory, so that she knows what to get at the market. Due to her husband's heart condition, they buy everything at the market for guaranteed quality.
Mary-Anne and her husband are well-traveled and spent some time in Europe when they were younger. They prefer to buy from local farmers and eat what is in season.

Cluster 2

Name: Cassandra Delmar
Age: 37
Location: Rondebosch
Status: Engaged
Job: Copywriter
Education: undergraduate level
Interests: Yoga, Socializing with friends, running
Social Media: predominantly active on Instagram.
Bio:
Cass is a 37-year-old copywriter who just got engaged. She stays in Rondebosch with her Fiancee and their cat, Muzzles. She strives to live a zero-waste lifestyle and recycles consistently. She spends weekends catching up with her friends at the market, and she shares her latest recipes and adventures on her Instagram page. She is still active on Facebook to keep up with high school classmates and her family.
Cass only buys some of her fresh produce at the market. It is usually dependent on the price and what is available. Sometimes she buys fresh produce to make something similar to what was made by her face food vlogger.

6.5 Information Architecture

At this stage, it is important to focus on the most important aspects of the application. During the market visits, the farmers and market managers provided lots of insights on what was needed for a food traceability application. However, this study focuses on the first iteration of the application. The most important aspects are focused on and then the application is incrementally improved based on the feedback. The output of this study is an application that allows individual entities, the market and farmers, to feed in data regarding the fresh produce. This data is then organized in a way that is easy for the customer to experience. The basis of

the organization is the information architecture.

To inform the information architecture, the process that takes place before a market is recorded. The interactions between the market manager and farmers is shown in Figure 1. The manager goes through this process with multiple farmers at a time. What is sold at the market is based on what is available. However, the manager also needs to ensure that she buys the quantity that meets the demand. This minimizes the amount of unsold produce at the end of the weekend, which cuts into the market's profits. The manager also needs to buy quantities that delay the selling out of the produce. Patrons who arrive after a specific produce has been sold tend to feel frustrated, which decreases their satisfaction with the market.

The market receives the most their produce from small scale farmers. The farmers sometimes grow variations of crops that are not normally found in supermarkets. Therefore, the markets tends to have small quantities of varieties of crops instead of a huge quantity of the same crop. The growing conditions of these crops differ as some are certified organic while some are heirloom crops that are grown without the use of pesticides. Knowledge of growing conditions is important to a subset of customers who specifically come to the market for the organic produce. Both personas highlight organic as an important factor of the market.

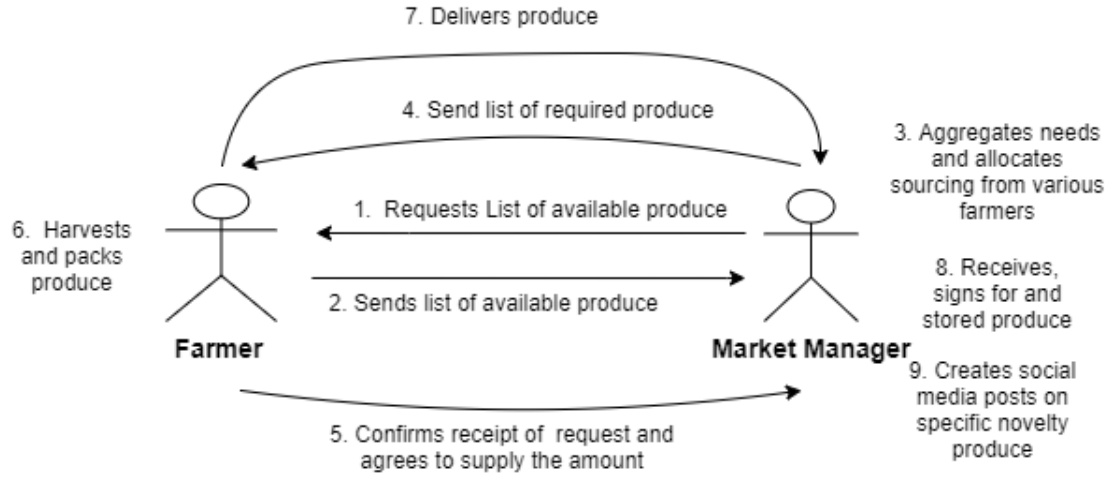


Figure 1: Numbered interactions that take place between the market and the farmers during the sourcing of produce.

Based on the discussion with the market manager and insights from user personas, I created a list of data elements required alongside the source and the state it would be in. Table 7 shows that the three sources of data are the market manager, farmers, and system administrator.

Element	Source	State
Fresh Produce	Market Manager	Dynamic
Fresh Produce Image	Market Manager	Dynamic
Producer	System Administrator	Static
Harvest Timestamp	Farmer	Dynamic
Warehouse Arrival Timestamp	Market Manager	Dynamic
Location of Producer	Farmer	Static
Producer Establishment year	Farmer	Static
Producer Story	Farmer	Static
Farming conditions/certification	Farmer	Dynamic
COVID response	Farmer	Static
Storage suggestions	Market Manager	Static

Table 7: The list of elements required based on the insights from farmers, market managers and user personas. Alongside them is their data sources and the state they will be in

Due to their respective states, the data is divided into three subsets. As shown in Table 7, subset 3 contains the dynamic information. The dynamic information will be sourced from the farmer and administrator. Subset 2 contains the static data that is entered by the market administrator concerning the fresh produce. Subset 1 contains the static data sourced from the producer.

Subset 1	Subset 2	Subset 3
		Unique Order ID
Producer (key)		**Producer (key)**
Location	**Fresh Produce (key)**	**Fresh Produce (key)**
Establishment year	**Storage suggestions**	**Fresh produce image**
Story	**Alternative name (s)**	**Harvest Timestamp**
COVID response		**Warehouse Arrival Timestamp**
		Farming Conditions

Table 8: The data subsets for the prototype and the elements present in each subset.

After setting out the subsets, the focus turns to the information architecture. The information architecture is designed with the expected behaviour of the users. The user is expected to access the application using a QR code that will be displayed at the market. The application is designed to be used at the market. As a result, it makes sense to place the point of access at the market. The market expects the user to wait in a socially distanced line before getting their turn to enter the market. This is a point where the user is expected to interact with the application.

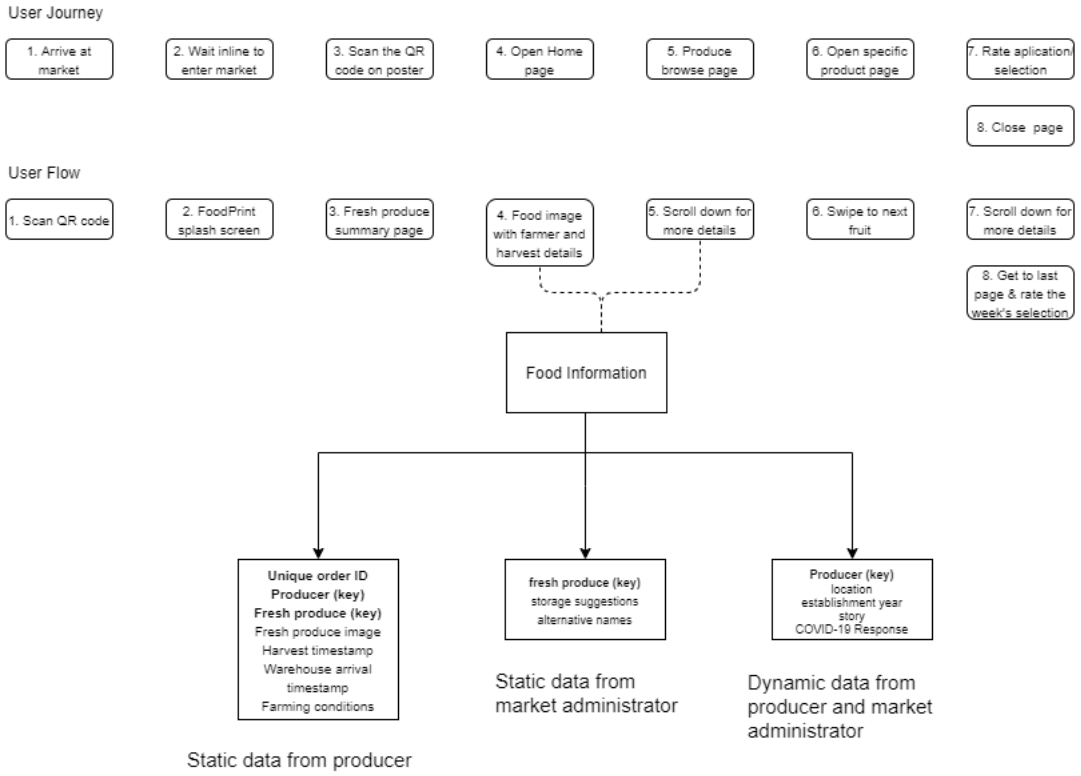
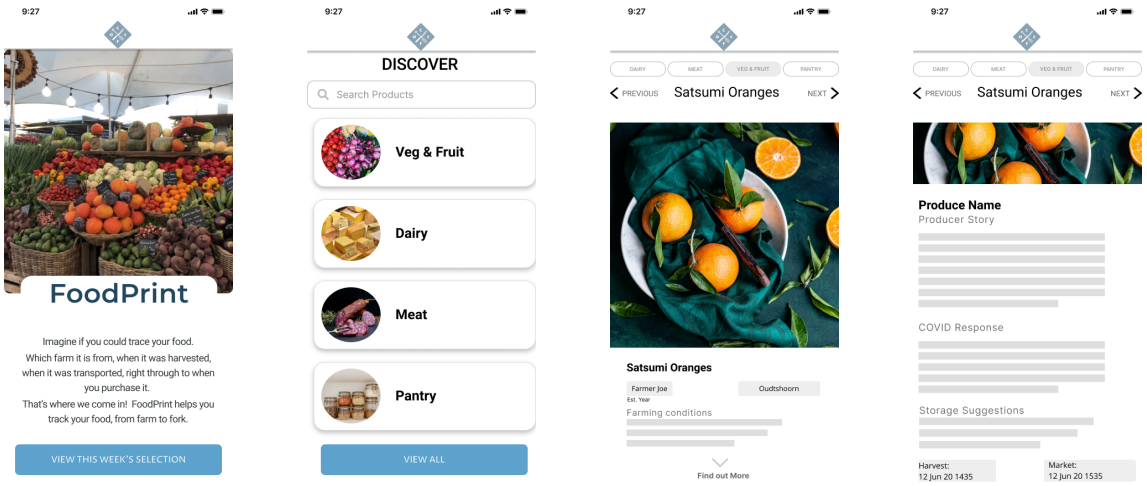


Figure 2: The user journey and user flow of the application. The user journey shows an overview of the different stages of the user's interaction with the product. The user flow shows the specific path that a user will follow when using the app. The information for each product offering is shown under food information alongside the dataset they will be sourced from

The path chosen is also informed by user behaviour at the market. The user flow and journey went through multiple iterations before the final one in Figure 2 was chosen. One of the initial ideas was to have a category page before the page listing the summarised produce. This idea was dismissed due to the segmentation of information. It is argued that when attending the market in person, many customers were observed to browse while shopping. By streamlining their access to information with categories, the browsing experience is taken away.

The information shown is a balance between what the market wants the users to know and the information users will need. The product page provides info that they might have been asked by the the market personnel. This project is only the first iteration, therefore there is a limit on the amount of information shared or interaction allowed. This is to limit the cognitive overload and to ensure that the



(a) Home (b) Navigation (c) Product (1) (d) Product (2)

Figure 3: Mid-fidelity prototype example

application provides the user with the information they need before the transaction finishes or they leave the page.

6.6 Prototype

After the information architecture is finalized, multiple designs are created. They are based on varying levels and combinations of the insights gained from the surveys, personas, observations, and market visits. They are continually analysed with the lesser ones being discarded at each iteration. An example of a mid-fidelity design is shown in Figure 3

The design minimizes active interaction and focuses on delivering information. If they scan the market-wide QR code they are directed to a home screen as seen on Figure 3a. After choosing the category they want, users are directed to a list of the products meeting within their chosen category. They click on each product to view more information about its origin and the farmer. They can toggle through the pages to access the products adjacent to it. The information flow is linear. The focus of the prototype is streamlined towards getting the user to the information.

If they scan the product-specific QR code, they are directed specifically to that product's information page as seen on Figure 3c. The only action needed is for them to scroll down in order to access more information. The mid-fidelity design is built into an interactive prototype. It is then sent for testing to the market personnel and people who attend the market. From the feedback, changes are made towards

a higher fidelity prototype that is built into a live version

6.6.1 Informal Testing of Mid Fidelity Design

In line with design thinking principles the mid fidelity design is made accessible to the customers at the market. The user feedback helps inform changes that need to be made to the design. It also provides a chance for the prototype to be tested in the environment and see how users interact with it.

Product specific QR codes are printed out and laminated on A3 white paper. The posters with the QR codes of 20 different fresh produce are placed around the market. They are placed in positions adjacent to the products that they are representing. Each poster has the name of the produce and the QR code printed on it. Therefore, customers are able to scan the QR codes with the cameras on their smartphones. They will then be redirected to the product specific page. If desired, they would be able to toggle between the produce information and the farmer information. Afterwards they can also access other fresh produce in the market by toggling left or right

Throughout the day the behaviour of the market's customers is observed to see how they interact with the posters and if they access the fresh produce. The positioning of the posters is also analysed from different points of view and times.

The customers are observed throughout the morning. This is to see how they interacted with the posters and if they actually scanned the app. The following is noted from the observations:

1. The call to action was hard to see 3 steps from the sign hence it would be required to increase the font size of the call to action.
2. Increasing the size of the posters will take up space usually used for fresh produce.
3. The QR codes have to be flat in order to be read by the camera. This requires a hard material that can withstand the wind as the market is next to the sea.
4. The glare from the early morning sun affects the ability for the camera to read the QR code. The QR code needs optimum conditions in order to be picked up by the camera.
5. The majority of the early morning shoppers are there specifically to shop, while those who spend more time browsing come later in the day.
6. The customer journey starts way before they arrive at the market. Social media and newsletters play a big role in the customer journey. So, it is important

to have the food print purpose and goal at the market in their subconscious before they arrive at the market.

From observations only a minority portion of the customers scan the QR code without moving closer to see what the call to action says. It was also noted that moving closer to the poster would impede on those who are choosing fresh produce. The placement of the posters hinders the organization of the fresh produce. This is unlike the small QR sign that is present at the payment point from SnapScan. The size minimizes the space taken up by the QR code. The customer is close to it and it is therefore effective even with the small size.

The entry to the market is a stopping zone for the market's customer as they sanitize their hands and have their temperature taken. It also has ample wall space for large posters that can be secured to it. Posters placed here can be made to be larger with more eyes on them. However, it will be to cluttered if the posters of all the fresh produce are placed on there.

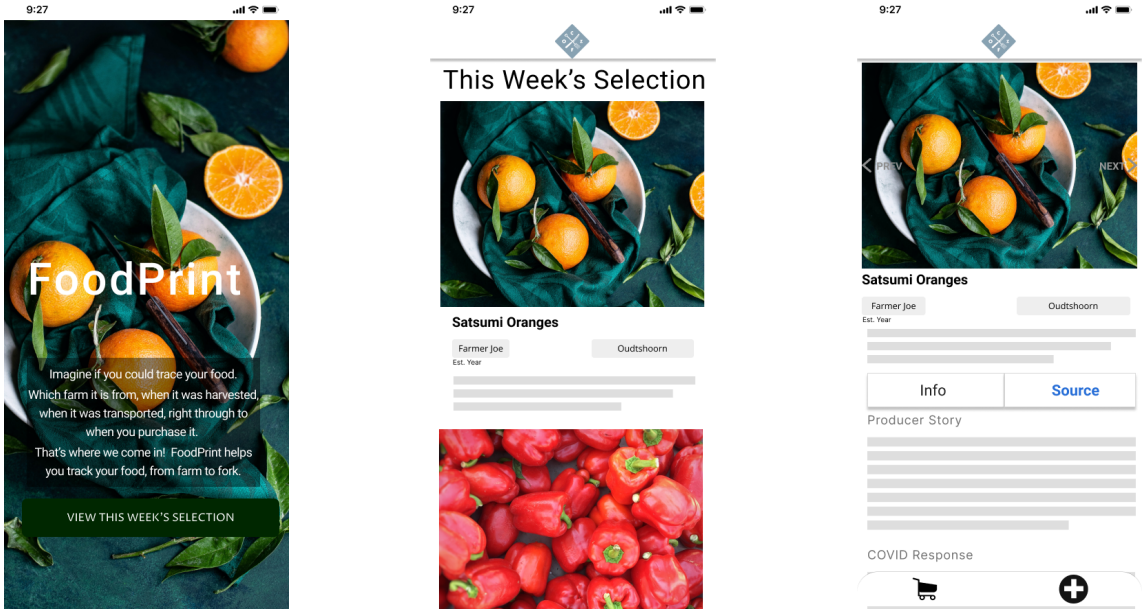
The posters are made of normal writing paper (80gsm) that is laminated. This is to minimize the damage from rain. However it is not steady enough to handle the wind present at the market. The wind is a mainstay at the market as the market is located next to the ocean. Other than the wind, the lamination is also susceptible to the glare of the sun. The sun and the wind cause glaring and bending, respectively. Both of these affect the ability of users to scan the QR codes. Steadier material that is not susceptible to the elements is required for the posters.

The timing of the various types of shoppers affects how the posters are interacted with throughout the day. The morning shoppers only scan the products they already plan on buying, while the afternoon shoppers are more curious and scan randomly as they go. Fresh produce that has been featured on the Market's social media pages also receive the majority of the attention. This leads to the conclusion that the customer journey for the web application starts before the market's customers arrive at the market.

All the findings are incorporated into the final prototype design. This design will be used for the SUS user testing.

6.6.2 High Fidelity Design

The high fidelity prototype is built for testing after feedback from users. Like the mid-fidelity prototype, users who scan the market-wide QR code will be redirected to a launch page briefly explaining what the application is for. This is informed by the fact that the most respondents in the survey only visit the market 1-2 times a month. The market also receives an influx of tourists who might not be familiar



(a) Home Screen (b) List Screen (c) Product Screen

Figure 4: High Fidelity Prototype

with the market.

From the launch screen, users go directly to the list of fresh produce available. The category page is not included. In order to improve discoverability for the niche of agricultural products available at the market, users can scroll through the list of fresh produce. From this view, they can see the name of the product, the farmer, farm location and whether it is organic or conventional. Just below that are a few sentences describing the product.

Users can click on the product they want to know more about. They are redirected to a page with the same information as before plus additional info on the farmer and the produce. The additional information is divided into two views that can be accessed by pressing either the "Profile" or "Origin" tabs.

Unlike prior designs, minimal scrolling is required and users can quickly glance at information that might interest them. The compacted information is easier to read while moving about and it is also easy to take a screenshot of them. This is consistent with the observations during the market visits where patrons were avid sharers of market images on their social media, and they also used their phones while socializing with others and browsing goods.

Another feature on each product's page is the bottom bar that allows users to add

products to a shopping list. They can screenshot the list and use it to keep track of their purchases. The feature is based on the user persona cluster of responses where 70% of respondents used shopping lists. The other user persona predominantly did not use shopping lists. However, patrons will, at times, have to queue before entering the market. This is as a result of social distancing measures. The patrons will have access to the market-wide QR code and can view the available produce provenance information beforehand. This is congruent with the market manager's intention to have the market be a source of information about sustainable farming, and for bringing the farmers closer to their end-consumer.

6.6.3 Site Architecture

The views that are rendered in the FoodPrint application are `Home` , `Product Navigation` and `Product`. As can be seen in Figure 5, the root component is called Main. It controls the switching of view amongst the three shaded components. Router's switch functionality is used to move between the three pages

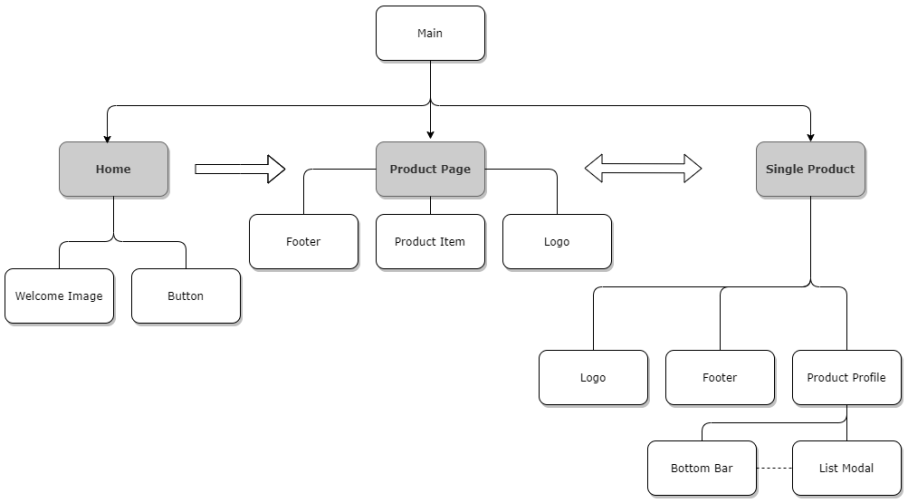


Figure 5: The component hierarchy of the final high fidelity prototype that is built into a live application for testing. The darkened components contain all the sub-components that create each of the three main pages in the application. The thick arrows show the user flow within the application.

The home page is the launch page welcoming visitors to the application. For the live site, this is the first page users see after scanning the QR code for the market view. The home page flows into the product page where all the loaded fresh produce is listed. Users can browse through the list until they reach a product of interest. Clicking anywhere on the fresh produce or its information redirects them to the

single product page for that. The single product page shows the entirety of the information for the specific product. Within the single product page. there is a functionality that allows users to add the current product to a shopping list and another that allows them to view the shopping list. The plus sign allows the user to add the product to the list. This shopping list is in a modal that is accessed by clicking the shopping basket icon.

The high fidelity prototype is built using javascript libraries, namely, React, Framer Motion, and React-Router. The backend is made up of a structured database together with blockchain distributed database. The static data is stored in the structured database and the dynamic data is stored on the blockchain. API keys are used to bring the data into the application for the users to view. Framer Motion is used to smooth out the transition between pages and interaction events. The loading animations are designed using the Framer Motion.

6.7 Testing

The remote usability testing was done on 5 people. They tested the application remotely and then proceeded to answer questions about the web application and food provenance. The first ten questions were based on the System Usability Scale (SUS). The remainder were for analysing the information provided within the application. All the participants enjoyed using the web application. However, there were complaints regarding the ease of use and flow of the web application.

The goal of the usability testing was to test the first iteration of the live market-wide application with an audience that was already familiar with the sustainable food movement and the farmer's market, specifically. The participants would answer questions by choosing a rating between 1 and 5; 1 meant they strongly disagreed and 5 meant they strongly agreed. The upper limit was to 5 and not 10 as the odd number of choices would show a clear positive, negative, or neutral choice.

The participants were customers of the farmer's market, however they all sourced their fresh produce predominantly from the supermarkets. The most preferred way of receiving data on fresh produce was a mobile application followed by WhatsApp stories. Both result in customers accessing the information via their mobile phones instead of a desktop, or in a paper format.

6.7.1 System Usability Scale Results

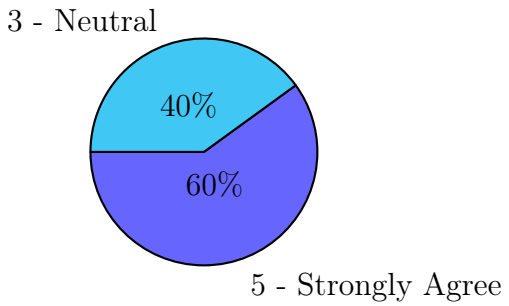
The industry average for the SUS score is 68.A score above 80 means the respondents enjoyed using the application and will recommend it to their friends. While, a score of 51 and under meant the usability of the site was not sufficient and needed to be fixed immediately.

The highest SUS score from a respondent was 95, while the lowest was 52.5. As seen in Table 9, resultant SUS score from the five respondents was 79.5.

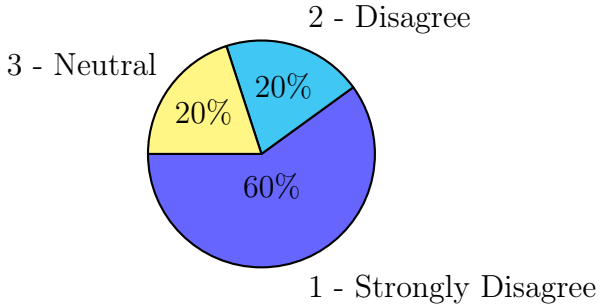
Respondent	**SUS Score**
1	95
2	52.5
3	95
4	85
5	70
Average	**79.5**

Table 9: The SUS Scores of the usability testing respondents that are calculated using the Likert scale.

The respondents were asked how challenging it was to use the web application. Based on the results Figure 6a, All the participants thought the web application was easy to use, responding with a score of 4 or 5. This aligns with the response to the question in Figure 6b, which shows that the participants did not know that they would need assistance to use the app. It can be deduced that the respondents will be able to easily utilize the app.



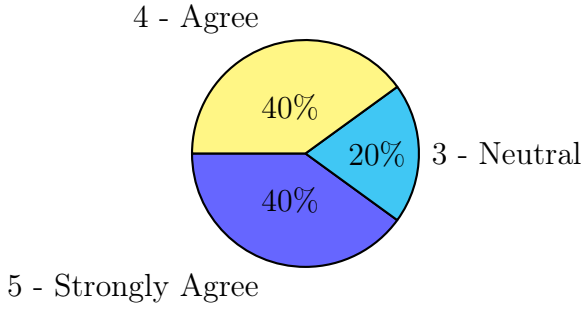
(a) Question: I thought this website was easy to use.



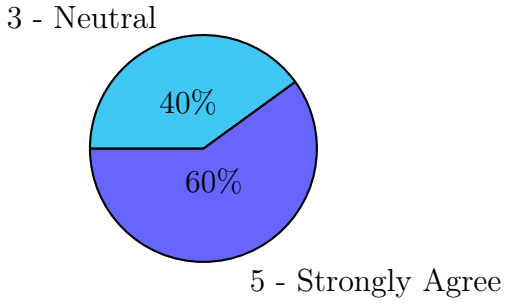
(b) Question: I think I would need assistance to be able to use this website.

Figure 6: Ease of Use

The overwhelming majority of the respondents found the various functions on the website well integrated. Only 1 of the respondents was neutral regarding the functions. As can be seen in Figure 7b, only 40% were neutral about their level of confidence using the application. Participants who feel confident using the application are more likely to use it more often as there is less friction due to the well integrated functions.



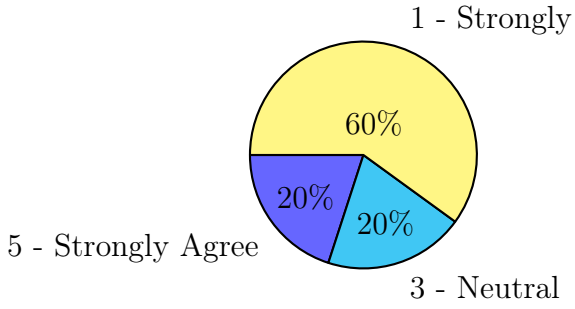
(a) Question: I found the various functions in this website well integrated.



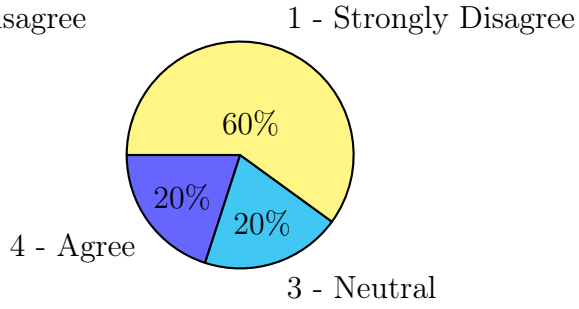
(b) Question: I feel very confident using this website.

Figure 7: Functionality & navigation.

When it came to the complexity of the website the majority (60%) did not find it complex. As shown in Figure 8a, while 1 participant did find it complex. This aligns with the response to question regarding the consistency within the website. A single peron's response agreed that there were inconsistencies within the website design, while 60% strongly disagreed. The same amount of people remained neutral. This means that the information architecture and visual presentation of information is predominantly good. However, there are issues as one of the participants did struggle through it.



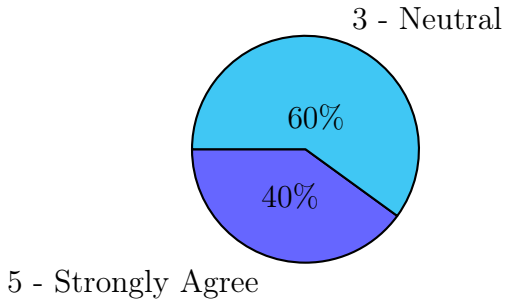
(a) Question: I found this website unnecessarily complex.



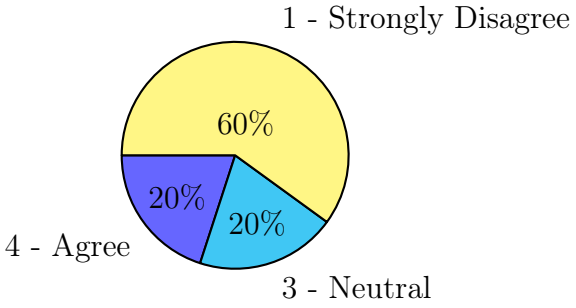
(b) Question: I thought there was too much inconsistency in this website.

Figure 8: Consistency & Complexity.

The majority of the participants were neutral when it came to whether or not they would use the web application frequently. As can be seen in Figure 9a, only 2 participants strongly agreed that they would use it frequently. The aim in future iterations is to improve upon the web application so that those who scored the question 3 would change it to 4 or 5. The participants were predominantly enthusiastic about the learning curve for most people. Only 1 respondent responded with a 3 (Figure 9b). The aim in future iterations is to improve upon the web application so that those who scored the question for frequent use 3 would change it to 4 or 5.



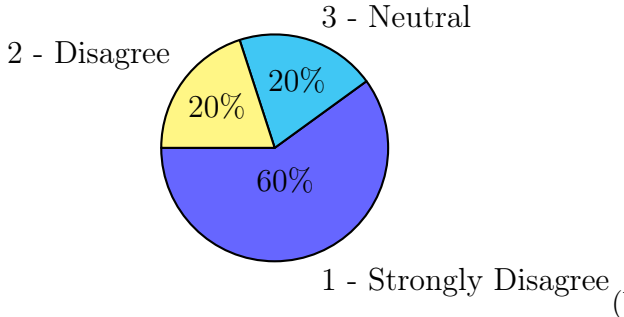
(a) Question: I think I would use this website frequently.



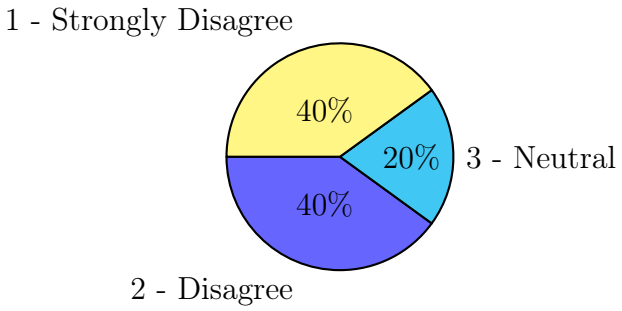
(b) Question: I would imagine that most people would learn to use this website very quickly.

Figure 9: Website Usage.

Figure 10a shows that the participants did not find the website awkward to use. They also did not have to spend lots of time learning how to use the website before carrying out the tasks as can be seen in Figure 10b. This means that the website is simple enough for users.



(a) Question: I find this website very cumbersome/awkward to use.

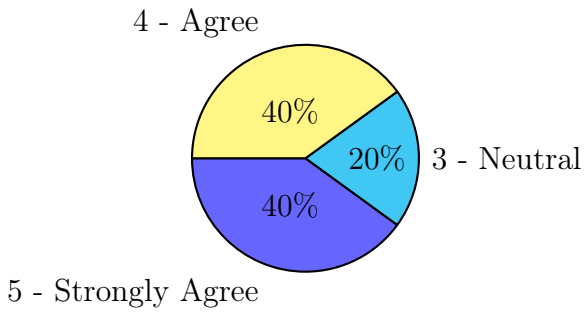


(b) Question: I needed to learn a lot of things before I could get going with this website.

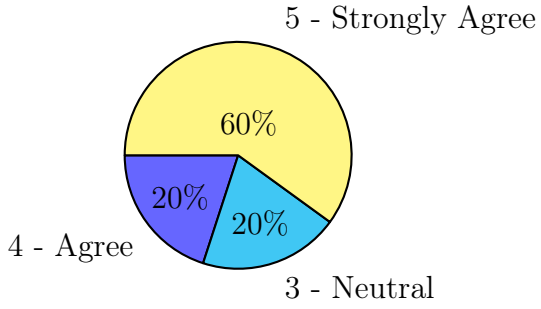
Figure 10: Website Usage.

6.7.2 Application Specific Results

The participants trusted the provenance information provided to them by the OZCF staff as can be seen in Figure 11a. However, they were also interested in the provenance of the products stocked by the other retailers at the market. This provides the opportunity for future iterations of the provenance web application to include all the traders at the market.



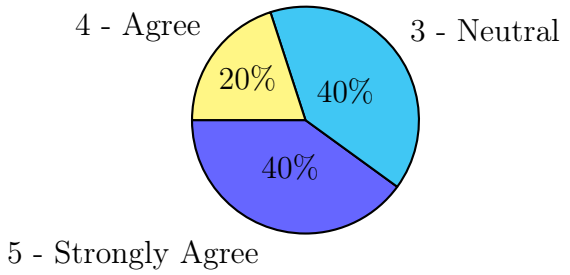
(a) Question: I trust OZCF when they tell about the food journey.



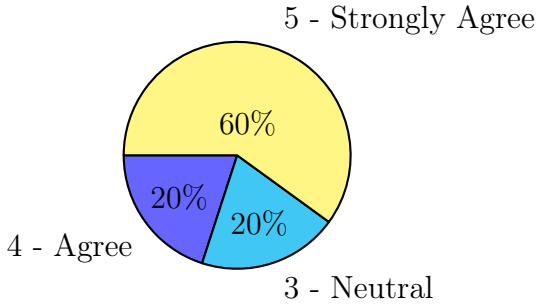
(b) Question: I am interested in the food journey for food stocked by other retailers.

Figure 11: Provenance.

The participants were mostly (40% were neutral) interested in interacting with the farmers who grow the fresh produce. This provides an opportunity to add in functionality that allows the users to communicate with the farmers. The participants also felt it was important that they know where their food comes from. This shows that the aim of the web application does have some demand amongst customers at the market.



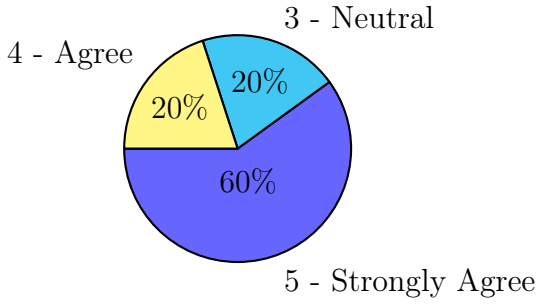
(a) Question: I would like to interact more with the farmers who grow the fresh produce.



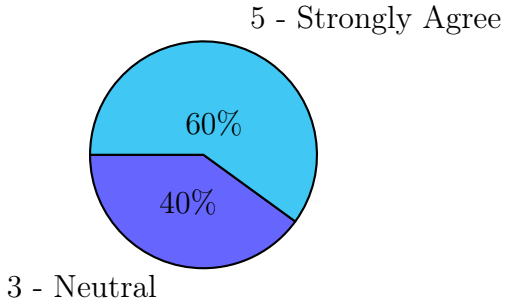
(b) Question: It is important for me as a consumer to know where the food comes from.

Figure 12: Farmer & Fresh Produce Information

Two of the questions pertained to the buying functionality. This was not active in this iteration of the prototype. However, it was one of the most important functionalities that the market administrators were interested in. As can be seen in Figure 13a & Figure 13b, there is interest in the buying functionality. The majority (60%), strongly agreed that they were more likely to purchase and through the web application.



(a) Question: After using the application I am further motivated to buy the fresh produce from the OZCF market



(b) Question: I am willing to buy fresh produce from this web application in the future.

Figure 13: Buying Functionality

The participants were asked to rate whether it was important for them to know specific types of information. When it came to pesticides, 60% of the respondent strongly agreed with knowing which pesticides were used in the farming process whilst the remainder were neutral. The same numbers were the output on whether

it was important for them to know how workers were being treated. When it came to the ownership structure, 40% strongly agreed on receiving this information whilst 20% strongly disagreed. The remainder were neutral.

6.7.3 Comments from Open-ended Questions

At the end, there was one open ended question for the participants. They were able to give comments on anything regarding the web application.

One of the participants wrote that the application had been so simple to go through that they wondered if they had missed something. Another user enjoyed using the shopping list functionality. There were multiple requests for a buying functionality to be added to the application. Another request was for the inclusion of video content. Visually, there was a comment on the lack of a product list on the home page. The users also complained about the lack of price information.

Some of the images of the fresh produce did not load from the database. There was a complaint regarding this. Participants also noted that they were not able to view information below the Covid Response header. One of the participants noted that there was no call to action.

7 Discussion & Conclusion

This study measures the usability of a live prototype of an early-stage blockchain based food provenance application named FoodPrint. It describes the human centred design approach. The author explored the use of design thinking and user experience principles to design a prototype based on blockchain technology. The deliverable for this study is a high fidelity prototype for the early-stage application.

In this study, I have demonstrated the concurrent use of design thinking and user experience design principles in the design process for the early-stage FoodPrint application. Through the application of HCD principles, the role in ensuring the usability of the blockchain-based web application has been shown.

The constant check-ins with the stakeholders throughout the design process has assisted in gaining new insights and opportunities for improvement. The result shows an overall usability score of 79.5. The majority of the respondents scored the user interface a usability score above 80, with only one scoring below average and one scoring just above average.

7.1 Analysis of Results

The use of design thinking principles in the earlier phases assisted in understanding the needs of the patrons at the OZCF market. During the visit to the markets, in the "empathize" phase, most of the patrons were using their phone to pay for the fresh produce or to take photos. This informed the decision to focus on a mobile-based web solution. The idea was further solidified by all the respondents during the usability testing choosing a mobile application as their most preferred option for receiving provenance information about fresh produce and farmers.

Both personas created during the "define" phase of design thinking attested to the importance of knowing the organic certification and farming process. This was incorporated into the web application by allowing farmers to enter the specific certification or farming process of their fresh produce. During the usability testing, 60% of the respondents strongly agreed with knowing the farming process. However, 60% were also neutral about their knowledge of farmers and the food they produced. This affirmed the market manager's emphasis on education within the platform itself. Insights that feed into each other were gained at the various stages of the design process.

During the market visits, social media influencers played a role in patron's buying decisions. This insight was noted but not incorporated into the design of the prototypes. However, one of the comments made during usability testing was to incorporate video content into the application. This aligns with the consumption of

short-form video content created by social media influencers through apps such as Instagram and WhatsApp.

In the similar work section, Abalobi allowed users to buy fish within their application. This functionality inspired the shopping list functionality in the web application. The shopping list feature was a success. It was especially mentioned in the open-ended question by respondents who enjoyed using it. However, based on the survey results used for the persona creation, only the respondents that fell into cluster 1 were using their phones for payments via the application SnapScan. As a result, the shopping list functionality was not developed further to include the option to buy. This was a mistake that was discovered during the usability testing phase when the respondents asked for prices and the buying functionality.

When designing the information architecture and user flow, the process went through multiple iterations. One option was to incorporate a category list before showing the lists of fresh produce whilst the other option was to start with the fresh produce from the get go. The former option would optimize the organization of data according to the information architecture. The latter option would remove an extra for the users on the user interface. The latter option was chosen in order to remove the segmentation of information that might lead the users to miss out on entire groups of fresh produce. However, during the usability testing phase, one of the patrons commented on the need for a list of vegetables available on the first page to make it easier to know what was available each week.

Evidently, the methodology that involved both user experience design and design thinking resulted in specific insights coming up repeatedly. This informed what was included in the high fidelity prototype of the early-stage application. With the inclusion of the SUS usability testing, the usability of the application was confirmed while providing insights that reinforced previous insights or provided new ones. This provides a basis for further innovation alongside the emerging technology, blockchain.

7.1.1 Implications

This study has methodological and practical implications. From a methodology point of view, this study has shown how HCD principles could be applied to the design process, and how the SUS usability testing can be applied to a small-scale design of a food provenance blockchain-based application. The process that has been applied in this study can be used as a frame of reference by teams developing early-stage web applications in emerging technologies such as blockchain. It takes into account the limitations in terms of time and resources, and it focuses more on the users instead of the underlying technology. The study provides a starting point when dealing with a complex emerging technology for real-world application.

Consequently, it provides opportunities in further studies to incrementally scale up the application of emerging technologies.

7.2 Research Questions Revisited

Research Question 1: How are user experience design and design thinking similar and different?

Design thinking is more focused on the researching and scoping activities that take place in the earlier phases of the process. This involves lots of interactions with stakeholders and end-users. While user experience design is focused on the aspects of the design process, it is more concerned with the actual product.

As seen in the study, the surveys, observations, and market visits are in-line with design thinking principles. The insight they provide guides on how the application's interface is structured and designed. User experience principles assist the structuring of the information architecture and user flow. They are designed to increase the efficiency of the application and decrease the friction for end-users.

Design thinking can therefore be seen as democratizing the user experience design process by including the inputs of end-users and stakeholders alongside those of designers and developers.

Research Question 2: How can design thinking be applied to blockchain-based supply chain web early-stage applications?

Design thinking brings in the insights of multiple stakeholders. By talking to multiple groups of people who would be using the end product, I have been able to understand the most essential features needed. I have also gotten insight into the environment in which the application would be used and whether the underlying technology itself needed to be brought to the forefront.

By focusing on what the blockchain technology is delivering instead of the delivery itself, I have been able to make sure that the end-product consists of information actually required by the end-user. The user interface design issues usually faced by blockchain application, such as jargon, are not present since the focus is on what is being delivered and not how it is being delivered. This results in the end-product being deemed easy to learn and use by the respondents of the usability test.

Research Question 3: How can user experience be applied to blockchain-based supply chain web early-stage applications?

User experience design used the outputs of the "empathize" and "define" stages of design thinking to create a product that is easy to use and enjoyable for users to interact with. With the information provided, user experience design focuses on why, what and how of the end product.

By integrating user experience design into the process, I have focused on why users would use the product, what the product would be able to do and how it could be put together in an accessible and aesthetically pleasing setup. This assists in ensuring that the end product's functionality is not overshadowed by the hype around blockchain, and instead focus on what the end product could do for the user. As seen in the study, the user journey, user flow and information architecture assisted in assembling the final product.

Research Question 4: How does the use of design thinking principles and user experience design affect the usability of a blockchain-based web early-stage application?

The use of design thinking principles and user experience design allows for the concurrent focus on the people who would use the application and the product itself. It assisted in keeping the focus on the value that the end-product would provide to users. As seen in the design, the use of both principles allows for the perceived value in the design and the perceived value from users to be continually tested and ensure that they are in line.

Additionally, design thinking is a non-linear process that allows for iterations between steps. As a result, continuous improvement of the prototypes is possible through the embedding of the user design process within design thinking. The result is an early-stage application that focuses on the core essential aspects of the app whilst providing an interface that is easy to learn and enjoyable to use.

7.3 Limitations

The study faced a number of limitations in terms of scope, testing population and technology.

The population samples of the survey and usability testing were limited to people who were already familiar with the OZCF market. This was decided based on the fact that the focus-group for the prototype was the market and its patrons. This limits the perception of the end-product to those who might already have some interest in it. It is advised in future work for the population sample to include those who are not familiar with the market or the sustainable food movement.

There were also technological constraints introduced by the inability to guarantee recording capabilities on the mobile devices of all those partaking in the usability testing. As a result, the screens of the respondents were not recorded during the testing sessions. However, a study by Peres, Pham, & Pillips (2013) found that there was a correlation between a user's performance on usability task completion and the corresponding SUS score. For future studies, it is recommended to also make use of other testing methods such as heuristic evaluations and moderated user testing.

The scope of the design did not look at the user experience and usability of the process of farmers and market managers entering data onto the blockchain. Instead, it focused solely on the perspective of the customers as the end-users. This was mainly due to a lack of time and manpower resources. Future studies are encouraged to increase their scope to the farmers and market managers. This is will assist in understanding whether the system as a whole is seamless before implementing other features or blockchain capabilities that will increase the complexity of the product.

7.3.1 Recommendations

The next iterations of the application are advised to focus on adding more functionality, increasing testing sample, scaling up the use of blockchain to test out issues with latency, and incorporating other forms of user testing that provide more insights.

The study successfully tested usability on an early-stage application with limited features. Thus, future practitioners are encouraged to add more features such as the aforementioned buying feature and video content. This will provide more opportunities to test out the interaction events and user experience.

The study showcased what the iterative process market managers go through during the procurement process in Figure 1. Therefore, it is encouraged to build upon this by researching the user experience and usability of the information uploading processes for market managers and farmers. This incrementally increases the complexity of the system and brings into play more functionalities of the blockchain beyond being a database.

The study was able to ascertain the usability of the early-stage web application using the System Usability Scale. Future studies may build upon this by also incorporating other forms of user testing such as heuristic evaluations and moderated testing. They will provide additional into the user interface interactions and physical responses by the users when using the application.

7.3.2 Conclusion

The purpose of this is study has been to explore how user experience design and design thinking principles enable the usability of a blockchain-based food provenance web application. The focus of early-stage application has been specifically for the OZCF market. They wish to provide their customers with an online source of information regarding the provenance of the fresh produce available at the market.

The user experience process has been embedded into the design thinking process in order to use both methods to design the early-stage application. The theory behind the underlying frameworks has been discussed. Furthermore, the steps and outputs of the combined process have been discussed, while showing how they feed into each other and allow for an iterative process.

The continuous input from stakeholders and the continuous testing with users has resulted in an application that has a satisfactory usability score. This has shown that the design thinking and user experience design principles are able to create an effective and successful early stage application.

References

A Survey

B Field Test

C SUS

D Ethics Approval