A Human Centred Design Analysis of Agtech Co-Development

The Case of FarmIQ

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Abstract

Over the past decade, the promise of agtech has far exceeded the reality of what has been delivered in benefits to farmers. This is often due to the technology's poor customer and user experience design. Faced with similar market failures with respect to product and service adoption, the business sector has developed an approach called human centred design as a tool to understand their customers' problems and design better customer experiences. To date, however, the use of human centred design to address similar market failures within the agtech sector has been limited. To evaluate this gap, this thesis undertook a case study analysis of a New Zealand agtech company, FarmIQ, who had developed farm management software with public money. Human centred design was used as the method in this research. Farmers and FarmIQ staff participated in this action research over a 17-month period to help FarmIQ with their challenge to gain sustained farmer adoption. During this time, interviews and workshops were conducted with current and potential farmer clients. The human centred design process revealed that even though FarmIQ had engaged extensive farmer input and developed sophisticated, world-class software, the subsequent adoption of their product was confined to a very small segment of the market. The farmer input had generated ideas and concepts which were somewhat more sophisticated than what the average farmer was willing to pay for and use. Using a series of iterative processes, farmers, researchers, FarmIQ staff and rural professionals participated in synthesis and testing to identify and validate the farmers' critical jobs-to-be-done that could be solved with technology. These findings were further developed and tested to reveal a minimum viable product and strategic options that would allow FarmIQ to confidently and better reposition and align their offerings with a majority segment of the farming population. The participatory nature of human centred design increased the capability of FarmIQ staff in co-design practices, enabling them to understand the benefits and challenges of a customer-centric approach and providing them with tools to better align products and services with the company's strategic aims.

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Chapter 1: Introduction

Although agricultural technology (agtech) has the potential to be an important and powerful tool for farming, technology companies and their offerings regularly fail to meet farmers' expectations. Consequently, even though farmers can see the potential gains, many have become increasingly ambivalent about adopting agtech due to the gap between the promised benefits and the reality delivered.

This thesis evaluates what the market offers through a case study of FarmIQ, an agtech start-up company. At the commencement of this study, FarmIQ had invested substantial resources to design and develop a cutting edge and integrated farming software solution with leading sheep and beef farmers. FarmIQ was established in 2010, a time when transformative agtech was coming along fast. FarmIQ had an overall programme which was divided into seven objectives, one of which aimed to provide farmers with a suite of technology-enabled software tools to manage their farming businesses and operations. The value proposition rested on the ability to capture critical data against individually identified livestock and to carry that data with the carcass along the red meat value chain, all the way through to the final consumer.

The FarmIQ product offering was developed using standard agile technology development processes[1]. This agile approach involved an incremental, test-driven process that focussed on the development of an agtech software package. As part of the software development, FarmIQ engaged volunteer farmers. These farmers formed a farmer reference group comprised of 12 IQ farmers, 48 focus group farmers and 300 farmers in a pilot programme (Isaacs, 2022). Within this reference group, there were leading farmers, a large corporate farming enterprise and a meat company. Using extensive interviews, surveys, analysis and user testing, FarmIQ identified problems that farmers wanted to solve on their farms. Understanding the potential solutions to this pool of problems became the basis of the technology solution platform that was developed.

[1] Agile practices and engaging end users was not common practice at the time that FarmIQ was designing and developing their products (Isaacs, 2022).

The initial product offering received favourable feedback from the farmers and investors who had been involved in the initial trailing and development process. FarmIQ therefore proceeded to commercialisation in August 2014. By July 2015, the FarmIQ System development team was awarded recognition and received positive endorsements[2]. However, despite these glowing endorsements and initial encouraging market signals, by November 2015, FarmIQ was struggling to create market cut through and convert farmer interest into long term adoption. There was limited and slow market growth. At the end of 2015, FarmIQ approached our project team to assist them in understanding why farmers were not adopting the software and asked for help to assist them through a human centred design (HCD) process.

The project team was made up of myself and an HCD facilitator. I was thus both the researcher for this thesis and a full participant in the project team. It is not customary to have the thesis writer involved fully in an HCD process, or that HCD processes are selected and undertaken with the anticipation that research data will be collected to inform a thesis. Given my involvement in the process under investigation, this case study falls within the field of action research (Reason & Bradbury, 2001). The thesis critically reflects on an attempt to transform FarmIQ by simultaneously undertaking and researching a complex series of HCD interactions. The HCD facilitator led and guided the project team activities, and following his advice we got to work by undertaking fieldwork in order to design the project scope. The project team wondered why the farmers who had participated in the software's development were not committing to paid subscriptions[3] with FarmIQ and why new sales were proving slow. On the face of it, it seemed like FarmIQ had undertaken all the right steps through their agile research and development processes. They had engaged and worked alongside innovative farmers with leading-edge ideas. The software and technology platform that had been developed was recognized as world-class. Market enthusiasm and positive signals indicated to FarmIQ that there was strong demand for their software. It seemed like there

[2] The FarmIQ 2015 Annual insights publication reported that the System development team had won the Discovering Gold category of the Wellington business community's annual awards. KPMG confirmed that the FarmIQ programme had credible outcomes and supporting farmers, noting especially the addition of environmental management software. KPMG did pick up the risk of not achieving short term outcomes, however, and amongst its recommendations was a call to accelerate the farmer use of the FarmIQ system (FarmIQ, 2015)..

[3] Farmers who were part of the initial development of FarmIQ had a free subscription. A high number of these farmers did not progress to a paid subscription (Isaacs, 2022).

was nothing the product could not do, such was its level of sophistication and ability to work with complex farm systems. Despite all this, however, was there a market failure of some kind? What was the understanding about self-employed farmers wanting to use the product when they didn't have to? We also wondered what solutions the technology offered for the farmers' most challenging jobs-to-be-done (JTBD). To answer these questions, the project team used an HCD double diamond approach. HCD was identified as the appropriate methodology as it offered the opportunity to synthesize and test the team's understanding frequently. Multiple iterations provided the opportunity to build a clearer picture of who the farmer was and to reveal what jobs they were trying to get done. We were able to unlock, unpack and understand patterns, and on this basis to identify the disconnects between technology, farmers and adoption.

When we started this work, it was not immediately clear why sales were declining. On the face of it, the in-depth work and analysis work before commercialisation had supported the direction that FarmIQ had taken. It seemed that the early work had enabled FarmIQ to accurately identify and develop its product for a predefined target market. We knew we had to dig back through FarmIQ's process to commercialisation in more detail to build our understanding.

From the beginning, FarmIQ's process had focused on the identification of opportunities to increase profitability along the value chain. This focus came from overall programme objectives and significantly influenced the development process. One example was the inclusion of Electronic Identification (EID) data so that individual animals could be identified. FarmIQ collected farm data by capturing and analysing animal EID records and workshopping with pilot groups. With positive feedback from this work, FarmIQ had then gathered 1,200 user stories. A solution was created to address every one of these user stories. This strategy inevitably resulted in a very high-tech suite of software products. It made the commercialised product more sophisticated than what "average" farmers wanted.

The project team wondered what the farmers made of this technology and, whether their views could shed light on the signs of market failure. Based on early scoping interviews with farmers, the project team soon realised that their first critical phase of work had to

concentrate on a discovery process of understanding and unbundling what the underlying business issues were for FarmIQ at the root level.

This process helped the project team to explore, experiment and validate which issues were the most pressing for a range of farmers. Through this process, three early insights emerged:

1. There was no clear understanding of who a farmer is. The term "farmer" applied to everyone.
2. There was no understanding of what the key JTBD was for farmers.
3. There was no clear understanding of the key problems in the marketplace that needed to be solved.

The previous work done by FarmIQ had captured what farmers *wanted*, but the *why* and *to-what-end(s)* were still in the farmers' heads. The project team found that farmers often have multiple roles and within each role there were multiple jobs that they were trying to get done. The FarmIQ solutions could solve all of them. However, it was difficult to access the software's functionality given that it was not aligned with the farmer roles or their associated JTBDs. Additionally, onboarding new farmers was far from easy. Onboarding was often highly complex and required the input of substantial data. This was well beyond the scope of many farmers' abilities and irrelevant to the problem at hand. It was not the frictionless experience that farmers were accustomed to with their rapid adoption of smartphone banking apps or accounting software. The costs involved in learning, adopting, onboarding and maintaining the software were substantial for both farmers and for FarmIQ.

The project team set out to identify the right way to access and assist farmers to complete their JTBDs from a strategic perspective. Additionally, how could FarmIQ create an appropriate service and technology offering to enable farmers to frictionlessly adopt the technology and complete their JTBD?

The critical insights unearthed by the team's research were that the farmers' most fundamental daily challenge was communicating with other people, and that their most useful tool was the farm map or farm photo hanging on the wall or in a ready to roll out place. This map featured whenever farmers were trying to explain something. This insight suggested that the base user experience for the software should be a digital farm map. While such a

map was already available as a central component of the FarmIQ software, it was overly complex and clunky to use[4]. The map needed to be reworked as the engagement interface for everything associated with the farm.

Research findings also suggested how to think about and implement strategically packaged agtech so that it aligned more closely with farmers' JTBDs. The use of HCD methods revealed generalised insights about agtech adoption and the need to uncover farmers' real problems. Discovering what their critical jobs were enabled the identification of low-hanging-fruit opportunities. On reflection, HCD also demonstrates the iterative nature of agtech development, with the need for a constant interplay between starting from scratch and repurposing, redefining and reusing what already existed.

More concretely, HCD processes yielded specific insights that resulted in a detailed understanding of the interface requirements for farmers relative to their JTBD. The project team also found that onboarding could be made considerably easier. The FarmIQ products needed to have the ability to be modularised. This would give the farmer the ability to pay for a package of services that could match their tailored needs with software solutions, instead of paying for services they didn't want or need. The specific segmentation of farmers was beyond the scope of this work. Instead, a 2x2 matrix was designed to represent the dynamic reality farmer JTBDs within their operating context.

The following five chapters that make up this thesis are organised to systematically present the research on HCD processes undertaken with FarmIQ.

Chapter 2 explains the FarmIQ case study in-depth as a background to the study.

Chapter 3 explains the literature which discusses traditional approaches to business design and some of its limitations. This includes market segmentation, a background of technology and innovation in agriculture and understanding farmer decision making processes. The literature review then introduces and explains design thinking and human-centred design and the key processes and methods which were used in this project.

[4] This was due to the available technology capability at the time (Isaacs, 2022).

Chapter 4 describes the methods which were used are used in the research are discussed in depth which includes the rationale and stages of design as a grounded theory and explains how each of the tools was used. This is arranged through a narrative structure over four phases of work.

Chapter 5 describes the results and discussion from the use of the methods. It follows the narrative structure established in Chapter 4.

Chapter 6 discusses the thesis achievements and reflections and concludes with the future of HCD.

Chapter 2: Company case study

2.1 Introduction

FarmIQ Systems (FarmIQ) was established in 2010 to support the development of the red meat industry through the delivery of the FarmIQ Primary Growth Partnership (PGP). One of the projects in this PGP developed an integrated farm management software system. However, by 2015 FarmIQ Systems was struggling with the lack of growth in software sales and stalled market development.

Through the development of the technology, FarmIQ Systems had interviewed thousands of farmers to understand their problems. Based on this work, FarmIQ developed software functionality to solve these farmer problems by using an agile approach which included the use of IQ farms, focus groups and piloting. This engagement with farmers helped to design the software specifications. Moreover, the pilot and focus groups reviewed the software as it was being built.

FarmIQ Systems relied heavily on its philosophy of collecting user stories and piloting with focus groups. The pilot work was coded and developed by an external software organisation, who built the pilot programmes using their own software and platforms. The software organisation was well embedded in the design process - they spent a lot of time with farmers. The development of the products was checked by the focus group farmers every week via sprint demonstrations. These approaches created two downstream problems. First, the piloting approach exposed a surface layer of farmer wants but it did not enable an understanding of their deeper underlying needs. There is no easy way to identify and understand these deep needs. They are often hard for people to describe explicitly, particularly in a group situation. Secondly, there was no process to check whether the approvals from focus group farmers would reflect what the wider farmer market would be willing to adopt. The taken approach provided for an efficient development of software solutions, but it also meant that there was no easy way to check whether the end products were something that the “average” farmer really needed and was prepared to pay for.

These problems with the design process remained unseen. The leadership team of FarmIQ Systems knew that the design of the architecture and core functionality of their technical solution was world-class. However, FarmIQ was soon struggling with how to appropriately package and present the technology as a viable value proposition to the marketplace to invigorate new sales and market share. A viable value proposition is built upon understanding where the user has unrealised gains, unresolved pain and unsatisfied jobs that they are trying to get done (A. Osterwalder, Pigneur, Bernarda, & Smith, 2014). The design process undertaken meant that these jobs were poorly understood and that the software would have trouble offering farmers a convincing value proposition.

By the end of 2014, FarmIQ had finalised and released their final version of products and services. By 2015, they had around 500 customers. This was a lot less than what was projected and planned for, and a troubling result given the considerable commitment of economic and personnel resourcing. Sales had stalled and there was no new market growth, a situation that prompted an initial discussion between the FarmIQ CEO and an HCD facilitator. A project team consisting of the HCD facilitator and I was formed.

Once formed, the project team had early interviews with the FarmIQ Senior Leadership Team and three farmers who were already using the FarmIQ systems. The farmers were found through networking and were interviewed using a semi structured format. The farmers described themselves as having an appetite for using advanced systems and using software solutions within their farming businesses. We analysed and organised the data from these interviews into key themes. This work revealed that the system was very advanced and well suited to users who were sophisticated, innovative and competent with using computer technology. Though these farmers had a high pain tolerance when it came to adopting new technology, even they found it hard to access the functionality of the farm management software (FMS). Clearly, the product which was commercialised was only suitable for a very small percentage of the target farming population.

As a whole, this thesis explores the ability of HCD to address such market problems. As part of the overall research, an analysis of the origins of FarmIQ and their development process was undertaken. This work would help us to understand the ability of the HCD process in contrast to the processes that FarmIQ undertook. The remainder of the chapter sets the stage for the

research by outlining the formation and nature of FarmIQ as an organisation and the work they undertook to develop its software products.

2.2 Origins of the FarmIQ Systems concept

The concept of FarmIQ Systems originated in the mid-2000s. At this time, continual market feedback from European and North American retailers indicated that there was potentially an opportunity for the New Zealand livestock sector to differentiate its red meat products in overseas markets. This differentiation could be based on a variety of attributes, including geography, genetics, production processing and assurance programmes. The initial FarmIQ concept evolved in discussions between PGG Wrightson and Silver Fern Farms (SFF), who were interested in exploring a whole of value chain approach across a tight group of strategic partners.

The proposed merger[5] between PGG Wrightson and SFF in 2008 put the value chain concept into the national spotlight as a key driver for the two companies coming together . The following excerpt from an *Otago Daily Times* article illustrates the early thinking between SFF and PGG Wrightson:

> …SFF was taking the meat industry in a new direction and away from the traditional supply patterns which were governed by grass growth, meaning most stock was supplied from December to May.
>
> Meat companies have been looking for new lamb markets away from European and United Kingdom markets and to reposition lamb as a high-value niche product, but these new markets wanted a year-round supply of lamb.
>
> Under the deal, SFF will outsource farm input, production services and stock procurement to PGG Wrightson with 100 SFF stock drafters to be integrated into PGG Wrightson's 280 field staff.
>
> SFF will manage logistics, processing, marketing and branding, in a deal being described as an integrated supply chain.

[5] The proposed merger required that the PGG Wrightson (PGG-W) farmer shareholders approved a deal whereby they would pay $200 million for a 50% stake in SFF, with the farmers retaining control. The merger failed in 2009, when mediation proceedings commenced after PGG-W failed to settle the first instalment of the subsequent transaction due to the Global Financial Crisis. In the end, due to an unresolved and long running dispute, the merger did not proceed (Wood, 2009).?

> The main obstacle currently preventing the industry from taking full advantage of this opportunity is the lack of co-ordination along the full length of the supply chain, from plate to pasture.
>
> "There is little scope for processors to influence on-farm practices, and thus production of consumer-specific animals," according to a white paper released on the subject" (Wallace, 2008)

The reasoning behind the proposed merger was based on the perceived need to assist New Zealand sheep and beef farmers to improve their pastoral farming practices and business outcomes. This instigated preliminary conversations about developing a FarmIQ Primary Growth Partnership (PGP). The conversation was motivated by the desire to build a market-led model that would increase red meat profitability along the value chain by generating sustainable product differentiation.

During 2008, a lamb value chain pilot was run in conjunction with Landcorp, the Livestock Improvement Corporation (LIC), PGG Wrightson, SFF and Tru-test[6]. The pilot comprised 48 progressive farmers from Canterbury, Southland and the Lower North Island. The pilot was built on intensive data collection from farmers with individual animal identification using EID. Though the process was very intensive and detailed, the participating farmers were very progressive and understood both the vision of the programme and the long-term benefits. At the end of the pilot, a series of workshops were held with participating farmers in Christchurch, Banks Peninsula, Dannevirke and Gore.

The results from the pilot were deemed to be a success. It was decided that the participating partners should submit an application for the first round of PGP funding.

During the business level case study, LIC withdrew before the PGP was finalised. They felt that their focus and energy were better spent on their dairy farming focus. Landcorp Farming Limited joined the project as a strategic partner. At this time, Landcorp was looking to build a

[6] Landcorp Farming Ltd is a State-Owned Enterprise with a nationwide portfolio of farms which produce beef, lamb, milk, venison and wood who operates under the name Pāmu (Pāmu:, 2022). LIC is a herd improvement and agri-technology cooperative who deliver genetic and technology to farmers (LIC, 2022). PGG Wrightson is a farm and horticultural supplies, wool marketing, real estate, water & irrigation and insurance services company (Wrightson, 2022). SFF is a New Zealand cooperative meat company. Tru-test is a farm techonogy company who specialises in livestock production systems, including animal weighing and electric fence technology (PDMA-NZ, 2022)

tailored, New Zealand friendly, FMS to replace their current Australian based system called PAM (Fairport, 2017).

2.3 Primary Growth Partnerships

The Primary Growth Partnership (PGP)[7] programmes were business-led, long term innovation investments to increase the market success of New Zealand primary industries which were co-funded by the New Zealand Ministry for Primary Industries[8] (MPI) (Ministry for Primary Industries, 2016). The overall goal of MPI at this time was to double the value of New Zealand exports by 2025.Through partnering with primary industry businesses, MPI aimed to assist innovation and research to boost and fund industry projects to increase economic benefits to New Zealand's gross domestic product (GDP) by $6.4 billion per annum from 2025 (Ministry for Primary Industries, 2016).

To be eligible for PGP funding, the rules stated that there must be a focus in one or more of the New Zealand primary industries, including pastoral, horticulture, seafood, forestry and wood processing, and run for no longer than seven years (Ministry for Primary Industries, 2017). All programmes had to be made up of complementary projects and be supported by industry co-investors, who supplied a minimum of $500,000 or 60% of the total investment over the life of the programme (Ministry for Primary Industries, 2017).

The PGP application process required that applicants first discuss their conceptual idea with MPI before drafting a proposal which then had to be checked for alignment with the PGP eligibility requirements (Ministry for Primary Industries, 2017). After this initial approval was received, a business case development process was completed by the co-investors and the Crown. This case was assessed by the Investment Advisory Panel who then advised the Director-General of MPI whether to approve overall. The FarmIQ proposal was submitted in

[7] The New Zealand Ministry for Primary Industries replaced PGPs in 2018 with a new programme called Sustainable Food & Fibre Futures (SFFF).
[8] In 2011, the Ministry of Agriculture and Forestry (MAF) merged with the Ministry of Fisheries and in 2012 MAF was renamed as MPI.

the first ever PGP round[9]. The applicants had to demonstrate that the proposed activities stated within the PGP were beyond their *business as usual* activities (Ministry for Primary Industries, 2017). The contracting process to implement the project occurred between MPI and co-investors once a finalised business case had been approved by the Director-General. The contracting process established the obligations between the parties for an investment partnership.

The final applicants for the FarmIQ PGP comprised a strategic business partnership between Landcorp, PGG Wrightson and SFF. Their vision was "to create a demand-driven, integrated value chain for red meat that delivers sustainable benefits to all participants" (From plate to pasture, 2010). It was proposed that the FarmIQ PGP would be achieved by building an understanding of the factors that impacted the eating experience of the final products and linking this to the delivery of better financial returns to members of the supply chain (Ministry for Primary Industries, 2016).

2.4 FarmIQ PGP process

The proposal concept passed the first round in 2009. Then the hard work started with the development of a comprehensive business case under the PGP funding rules and regulations for the then New Zealand Ministry of Agriculture and Fisheries (MAF)[10]. Deloitte was contracted to develop the business case by the strategic business partners and MAF. The PGP Business Plan detailed seven different projects:

1. Market analysis
2. Database
3. Genetics
4. Processing phenotype collection
5. Processing improvements
6. Technology transfer
7. Farm productivity capacity

[9] Organisations were able to submit a PGP programme proposal at any time; however, at the time of the FarmIQ application, there were annual funding rounds (Ministry for Primary Industries, 2017).

[10] Referenced as MAF at this time due to rename as MPI occurred in 2010.

These seven programmes of work were designed to deliver four primary outcomes:

1. Increased sustainability of the red meat sector
2. Increased collaboration between sector participants
3. Increased productive capacity
4. Increased ability to produce products to consumer specifications (From plate to pasture, 2010).

The Business Plan presented how the PGP would contribute towards the transformation of the New Zealand red meat industry through identifying the needs of the industry and delivering an estimated net economic benefit to the New Zealand economy of $8.8 billion by the year 2025 (From plate to pasture, 2010). The analysis of the current supply chain structure concluded that it was dysfunctional, inefficient, and production-driven, all of which contributed to various market failures and a collective trading focus on converting meat to cash as quickly as possible (From plate to pasture, 2010). In response, one of the cornerstone projects was the building of a farm-centric information system that enabled an understanding of production system linkages, including changes to meat yield, yields to live weight, meat quality, economic benefits and the carbon cost of meat. This was to be done through the collection of data from the millions of individual animals which are finished on New Zealand farms (From plate to pasture, 2010).

The business plan recognised the risks associated with the programme. These risks were derived from previous research and the pilot programmes, as well as from collaborative meetings and communication with MAF. The business plan was confident that the identified risks could be managed and/or mitigated through the "robust and transparent processes" that were in place, based on best practice. This included a four-step process of identification, assessment, mitigation and continual evaluation (From plate to pasture, 2010). See *Table 1* for the identified risks identified in the overall PGP Business Plan. As the Table shows, the possibility that the data would not be useful was thought to be low and the risks of low uptake consequently no more than medium.

The Business Plan also acknowledged that farmer uptake was vital. Accordingly, the farming customer segment was broken into three categories; early adopters, followers and resistant to change. The general feeling amongst the partners was that the early adopters would take

to the technology regardless of who they supplied meat to. The followers would come along quickly upon hearing about the technology's successes and early benefits derived through the programme by the early adopters (From plate to pasture, 2010). The business plan did not concern itself with those who were "resistant to change".

Impact	Risk	Management and mitigation	Likelihood
High	Farmer uptake and inability to manage farmer expectation	The recruitment of animals managed under the Programme and the number of farmers participating is a leading indicator of the success of our Programme. Farmers have to change, this is a key focus for our Programme.	Medium
High	Lack of customer uptake	Our consultation to date suggests that this is not a high risk. However, we are mitigating risks associated with the customer and their needs through the market stream sub-project which is developing the capability to determine customer requirements	Medium
High	Data are not useful	This is a risk with high severity but low probability. We are mitigating risk currently through well planned pilot programmes which canvas the usability of information collected and the ability to make positive changes using that information. To date, this has been achieved.	

Table 1: Identified risks in overall FarmIQ business plan. (Source*: From plate to pasture, 2010*).

2.5 Formation of FarmIQ Systems Ltd

By 2010 the PGP application was accepted and NewCo[11] was born with five partners, PGG Wrightson, MAF, SFF, Landcorp and Tru-Test. During this time, the search for new and additional farmers who would fit in with the programme began. At the end of 2010, a CEO was appointed and NewCo was now operating under the name of FarmIQ Systems Ltd. FarmIQ divided the programme into six projects; Management, Processing, Market Analysis, Genetics, Farm Productivity and FarmIQ Database, each having its own detailed performance indicators to measure progress (FarmIQ Systems Limited, 2011).

Work commenced at the beginning of 2011 to establish a small team. Their first task was to identify what product and service offerings were going to comprise the FarmIQ technology. In July 2011 PGG Wrightson left the programme and Landcorp and SFF agreed to underwrite the PGG Wrightson contribution. In addition to the four remaining partners, there were 10 preferred suppliers. By the end of 2011 there were 250 FarmIQ participant farmers. The 2011 end of year insights reported that the red meat industry's profitability had significantly increased due to a shortage of supply, a situation which created advantages and challenges for FarmIQ systems (FarmIQ Systems Limited, 2011). The 2011 report indicated that overall the FarmIQ programme was operating confidently and well positioned to consolidate and refine any design work. In addition, there was enthusiasm reported from the "IQ" farmers and optimism was high that the FarmIQ System was well aligned with industry needs (FarmIQ Systems Limited, 2011).

From 2011 until 2014, a series of scoping FMS pilot programmes were run. The initial pilot programme was run with staff and owners from 12 different farms of varying size and land use. This early work collected and analysed user stories to build the first pilot software by an external software provider, who used their own systems and platforms. From this initial pilot, 300 farmers and potential end-users were engaged from a variety of geographies, farm types and sizes. These 300 farmers generated 1,200 user stories. However, it was also identified

[11] NewCo was the initial working name of the FarmIQ PGP and FarmIQ Systems.

that one of the obstacles during the pilot process was that perhaps some of the participants were dragged along and group think had emerged (Isaacs, 2015).

Solutions were built to service the 1,200 user stories that had been collected. From 2013 until 2014, pilot programmes were run to test and develop versions of the FMS. Feedback from the farmers was gathered during this phase. FarmIQ collected feedback using emails and through their field business managers. Some of the feedback from farmers who dropped off during this process indicated that there was frustration at how progress was going and how the programme was developing. It was easy for FarmIQ to find a broad number of farmers who were willing to take part in the pilot process. However, it was hard to find the same number of dedicated farmers who could commit the necessary time and resources needed to fully develop the programme (Isaacs, 2015).

The pilot work primarily focussed on tracing and measuring individual animal and performance data collection using EID's. It did not look at the possibility of mapping, compliance and land use in great depth. The resulting mainstream system was trialled and tested by Landcorp Farming Ltd[12] during 2014 before it was commercialised. Through the continuous iteration of improvements, FarmIQ was confident that they had created a highly functional system.

By the end of 2014, FarmIQ Systems announced that they were going to implement their strategy to make their FMS system available on mobile devices because farmers were wanting to use technology away from their home computers (FarmIQ Systems Limited, 2014)[13]. They had also finalised and released version five of the FMS which offered five system packs to farmers (FarmIQ Systems Limited, 2014).

By mid-2015 FarmIQ Systems was in an advanced development state and had been adopted by around 500 farmers. However, this was considerably less than what was desired or expected for this stage of the programme development and given the considerable economic and personnel resourcing being spent on the project, new sales for the FMS had stalled. A summary FarmIQ Systems development journey as outlined above is shown in *Figure 1*. This

[12] Landcorp launched Pamu as its product brand name in 2015 (Scoop Business, 2017).
[13] Smartphone phones were beginning to be mass adopted at this time.

summary shows the number of processes that FarmIQ followed from concept to commercialisation which included a high degree of farmer participation. So why the stalled sales?

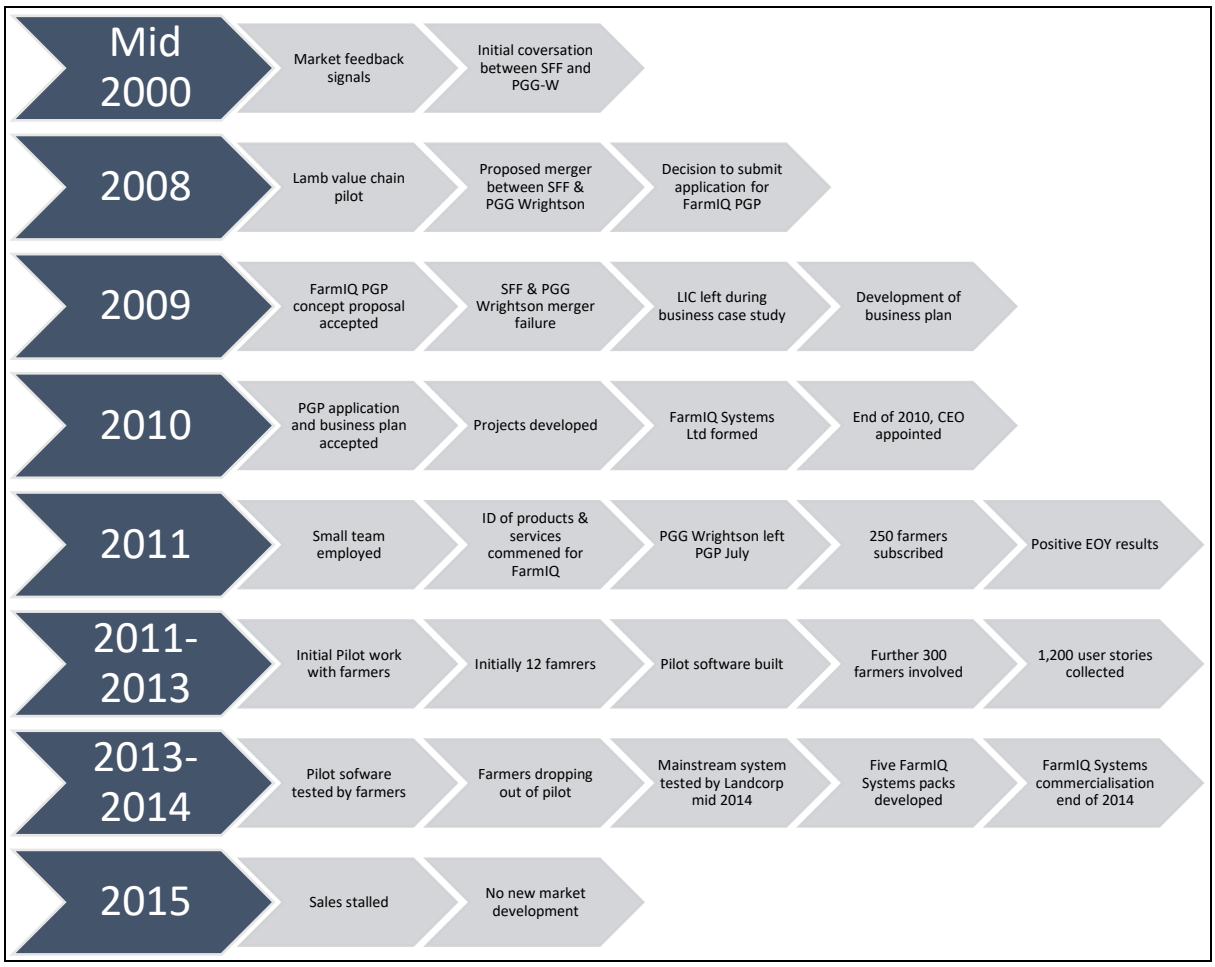

Figure 1: Summary of the FarmIQ development timeline.

The CEO came to realise that the issue of stalled sales didn't exist as a simple marketing problem, and he knew that there was more complexity to identifying the root of the problem and the solution. Neither of these were obvious or easy to pinpoint. At this point, he engaged with the project team to seek help. The CEO was curious about what a different approach such as HCD might surface.

The above case study has provided the thesis with the context and methods that FarmIQ used to develop its FMS. Now the thesis will be informed through the examination of the literature.

Chapter 3: Literature review

3.1 Introduction

This chapter provides a general overview of human centred design (HCD) by reviewing the relevant literature. I begin by summarising classical business development processes in order to demonstrate the limitations of these approaches that HCD aims to overcome. I explore issues related to the development of agricultural technology in particular, as well as the limitations of classical customer segmentation approaches. Against this background, HCD is introduced, focusing in particular on the techniques for and benefits from gaining user involvement in the design of products and services. The chapter concludes with a discussion about using design thinking tools and teams within in established organisations.

3.2 The problem with business plans

The traditional approach to business planning in a complex and fast changing environment is stifling innovation and development when there is a lack of interplay between internal and external business environments(Franca, Broman, Robert, Basile, & Trygg, 2017). The business planning approach often does not actively engage potential customers and end-users in innovation processes. Indeed, technology and engineering organisations will often begin with the solution already in hand, which is then pushed into the market to test the presence and level of need (Beckman & Barry, 2007). Though the express testing of products and solutions has gained some popularity and does offer the opportunity to make improvements, the risk is that while product and service usability can be tested, there is often no ability or opportunity to study and understand the real needs of the customer and the end-user, despite the fact that these needs are a critical factor in creating successful innovation (Beckman & Barry, 2007).

Business plans are typically accompanied by a proportionally large investment in resources – they lack the benefit of having exploratory options and are consequently quite static in their sense of what the future holds. A static state can make organisations “flat footed” which compromises a firms ability to respond to the needs of its external stakeholders (Joyce & Paquin, 2016). The static state of an established and classically designed business creates a

large amount of sunk cost and fixed investments, something which limits the organisation's ability to explore richer possibilities (Day & Schoemaker, 2016). Though many organisations have admirable strategic intent, firm performance can only be realised when these strategic intentions are able to be executed and that requires a flexibility that is often lacking (Day & Schoemaker, 2016).

Traditional business plans and strategy processes are constantly lumbered with lengthy internal debates. These tend to a high investment in budgeting, processes and multi-year planning, further cementing the organisation in a static state and limiting its ability to identify and respond to market advantages (Day & Schoemaker, 2016).Traditional value creation is often bound and analysed by units of output. When output becomes a mere measure, the important outcome question of what it is that the customer really needs can be lost (Bettencourt, Lusch, & Vargo, 2014). There is no value realised when a customer doesn't rely on the service or good produced by an organisation to get their job accomplished (Bettencourt et al., 2014).

The need to focus on the end customer and their world is vital. Research has found evidence that often when projects are funded publicly, organisations fail to plan how to bridge the gap between customer knowledge and their business ecosystem (Clarysse, Wright, Bruneel, & Mahajan, 2014). Customer intimacy is part of robust business model innovation. This can be overlooked when strong emphasis is given to breaking into new innovative accomplishments at the fringes of technological frontiers (Autio, Kenney, Mustar, Siegel, & Wright, 2014).

3.3 Understanding the customer's world

Obviously, the concept of marketing is not a new notion in the world of business. However, though the idea here is to promote a focus on the customer, the reality is that firms are most often focussed on themselves, with much emphasis and effort placed in trying to sell more of what the firm already produces (Bettencourt et al., 2014). This goods-dominant logic has its roots in a production-based school of thought which fails to recognise and collaboratively appreciate the need for value creation in line with a customer or end-user "job to be done" (Bettencourt et al., 2014; Vargo & Lusch, 2008).

On the face of it, organisations believe that they are behaving in a customer centric manner. However, many organisations constrain themselves to only demographic information which restricts the firm's ability to really come to deeply understand their customers and how they can focus on creating value for them (Bettencourt et al., 2014). Value for the firm and for the customer can be enhanced when salient needs, behaviour and wants of the target customer are identified (Autio & Acs, 2010; Autio et al., 2014; Davidsson, 2006; Phan, 2004). Understanding the behaviour of customers when they adopt and when they abandon technology can create important insight to inform the firm on strategies for growth (Autio & Acs, 2010; Autio et al., 2014).

Often, businesses are consumed with creating or increasing "things". The shortfall of this thinking is that such things or resources are not able to deliver any form of value unless there is some form of additional action (Bettencourt et al., 2014; Vargo & Lusch, 2008). It is proposed that to co-create value for customers, a shift needs to occur which will eliminate such mental barriers for action (Bettencourt et al., 2014; Vargo & Lusch, 2008). This is the difference between operand and operant resources. Operand resources are linked to things that are usually tangible and static, needing some method of action to make them valuable; operant resources, on the other hand, are dynamic and are usually intangible creators of value (Bettencourt et al., 2014; Vargo & Lusch, 2008). There is a tendency for decision-makers to constantly overestimate the amount of value that others place in product and service(s) offerings, resulting in an inclination for people to align their own preferences and thoughts with what they think their end-users want (Liedtka, 2015; Van Boven, Dunning, & Loewenstein, 2000).

3.4 Technology and innovation in agriculture

The role of technology and information systems is also relevant to this thesis as part of an innovation partnership between the people and technology. To provide important context, it is relevant to understand the origins and developments of farm agtech.

Information systems for farms appeared during the 1970s and were used for tasks such as recordkeeping and planning in relation to irrigation, pest management and the application of fertilizer (Blackie, 1976; Thompson. S.C., 1976). During the mid-1980s, algorithms were

further developed in four main areas: inventory data, daily farm operations data, annual data linked to seasons and processing permanent data which seldom changes (Fountas et al., 2015; Kok & Gauthier, 1986). The first used example of these combined decision-making tools was in a cropping situation in California (Plant, 1989). Since then, however, precision agriculture has taken advantage of developments in information and technology which allows farmers to acquire data to lessen decision making doubts, improve financial returns and reduce their environmental impacts (Fountas, Wulfsohn, Blackmore, Jacobsen, & Pedersen, 2006).

Today's Farm Management Information Systems (FMIS) can be as simple as farm recordkeeping arrangements through to more complex and sophisticated systems which are designed to help support farm production and management, reduce production costs, increase product quality and to provide a means to fulfil compliance matters such as health and safety (Fountas et al., 2015). Farm Management Information Systems have been described as a tool for gathering, processing and providing information that can be used for making or supporting farming managerial decisions (Boehlje & Eidman, 1984; Lewis, 1988; G. C. Sorensen et al., 2010). This being said, the decisions which are made on farms are made complex due to the impacts of weather, biological influences, supply and characteristics of land and market forces (Kay & Edwards, 1999). A goal is to create systems which help farmers to sort information in a logical manner when they are faced with making decisions and form plans, without being overloaded with unnecessary or irrelevant information (C. G. Sorensen et al., 2010).

It is also increasingly common for agricultural stakeholders of various kinds to require data from farmers and other value chain partners for the purposes of adding value to their own strategic and management processes (Fountas et al., 2015) and to meet increasing consumer demand for information about the origin, safety and integrity of food (K. G. Grunert, Bredahl, & Brunsø, 2004; K.G. Grunert, Larson, Madsen, & Baadsgaard, 1997; Luvisi et al., 2011; Thilmany, Umberger, & Ziehl, 2006).

Technology use in precision agriculture has expanded exponentially with the introduction of Global Positioning Systems (GPS), though research has found evidence that the adoption of technology has not driven forward in scale past the first moving technocratic customers in the market place who can be perhaps be over enthusiastic with their feedback (Lamb, Frazier, &

Adams, 2008). This type of feedback sends the wrong messages back to the organisation as it is catering for a very narrow segment of the market, thus denying understanding the needs of the average customer.

3.5 Understanding the farmer decision-making process

Previous research about farm information management has drawn criticism for its lack of quality information about how farmers actually select, assess and use information to make decisions (Just & Zilberman. D., 2003; Magne, Cerf, & Ingrand, 2010). The amount of farmer involvement and participation throughout innovation processes including, problem definition, model design, subsequent testing and evaluation is often very limited (Woodward, Romera, Beskow, & Lovatt, 2008). This has resulted in the delivery of poor observable impact and benefits (Woodward et al., 2008). Research has found that there has been considerable wastage of investment money, with poor farmer uptake of decision support systems designed to assist and improve agricultural practices and increasing concern amongst research and development funding bodies (Cox, 1996). One reason for this could be that farmers use their intuition to make decisions rather than using planning tools of a formalised nature which therefore presses the importance of teasing out farmer planning practices (C. G. Sorensen et al., 2010).

Today's world has seen a vast increase in the amount of readily accessible information and data that are available to farmers from a variety of sources (Carberry et al., 2002; Mugnier, Magne, Pailleux, Poupart, & Ingrand, 2012). Though there is a plethora of information available, the problem lies with the struggle of discovering and choosing that which is relevant to their situation in a manner which is cost effective and capable of being adapted into highly diverse farm management systems and strategies (Brook, 1988; Just & Zilberman. D., 2003; Kay & Edwards, 1999; Magne et al., 2010; Stafford, 2000; Thysen, 2000). Research has identified that there is a need to recognise and develop improvements in both the understanding of commercial and academic applications of technology uptake. In particular, the motivations, limitations and the deterrents to technology adoption, and how to better design technology which is user friendly for farmers (Fountas et al., 2015). It is also important to consider information formatting and the analytic capability of farmers (Just & Zilberman. D., 2003).

Fountas et al. (2015) identify the lack of crossover between academic research and commercial applications of farming technology as a significant problem. While academia concentrates on very complex systems, commercial applications focus more on operational, daily tasks with a view to increasing income.

3.6 Challenges with common software development

While understanding the specifics of farmer adoption of technology is a key focus, it is important to understand more general software development practices. FarmIQ were developing software in a dynamic environment which at the time, had limited methods to follow.

Software development and design are typical of the current product development world, which is forced to operate in fiercely dynamic and competitive environments, made even more so with shorter lead times, fast-paced technology evolution, diverse demand factors and shortening product life expectancy (Kettunen, 2009). Two of the most common methodologies used in software design and development are waterfall and agile. The value of these two approaches has been a matter of considerable debate. The waterfall method is a linear software development process with six steps; determine requirements, design system framework, implement project, test product, release to public (Kalso, 2020). Through this monolithic approach, firms can obtain a sense of progress towards a final product (Benediktsson, Dalcher, & Thorbergsson, 2006). Waterfall gains its name from the nature of the vertically arranged phases which flows in only one direction, downward (Kalso, 2020). The waterfall approach was refined in the 1970s to meet the increasing size and complexity of software projects and to provide order and structure to their development processes. It is criticised for its constrained and uncompromising approach (Kalso, 2020), however, it also has merit in projects which have a very stable environment (Thummadi & Lyytinen, 2020) .

In contrast, agile approaches are incremental and flexible, they are seen as less risky than the traditional waterfall methodology, especially in large and dynamic software projects (Pillai, Pundir, & Ganapathy, 2012; Ruhe & The, 2004). Agile was a relativity new practice in the period that FarmIQ was developing their software system (Isaacs, 2022). Through agile software development, small teams are utilised and the client or end-user is included in the

process by being offered the opportunity to give evaluative feedback on the product which may include improvements or changes and also help to identify priorities and constraints (Benediktsson et al., 2006; Ruhe & The, 2004). This incremental approach increases the likelihood of initially delivering software which addresses users' precedence requirements, hence simultaneously increasing customer satisfaction and market share while decreasing time and monetary overruns (Benediktsson et al., 2006; Ruhe & The, 2004). This is not to say that the development is completed based on a minimum offering, but rather that unimportant features do not crowd the initial offering to the market. Customers who adopt early are likely to provide feedback on improvement and are inclined to support the system in the future (Ruhe & The, 2004). In addition, changes to the requirements of the client or end-user are able to be acted upon (Ruhe & The, 2004). Choosing which approach to adopt can be a challenge in software projects. An evaluation of personnel, capabilities, requirements volatility, group culture, group size and application criticality are useful attributes to consider when making this decision (Benediktsson et al., 2006).

Software development activities are on the increase and waterfall and agile approaches remain popular approaches. However, the needs of the business are often not met with either approach because projects are late and the delivery flow is small – all of which creates what is called a value gap (Pass & Ronen, 2014). Value gaps are created due to a lack of understanding of what creates value and how software could contribute because;

- project costs often run over budget;
- the requirements of the software are not clearly defined and;
- the creation of packages which do not provide solutions are often abandoned (Pass & Ronen, 2014).

Even though FarmIQ had a high degree of farmer involvement in the development processes, there were problems with farmer adoption.

3.7 Classical technology uptake model

The "Technology Life Cycle Adoption Curve" is a sociological model which was has its origins in a model called the diffusion process which was applied in agriculture and home economics (Beal, 1956). Based in an agricultural context, the five stages of diffusion are awareness,

interest, evaluation, trial and adoption based on what was in the real minds of farmers (Beal, 1956). Initially, the diffusion process was a technique used to understand the farmer adoption of hybrid corn (Ryan & Gross, 1943). This was advanced in 1962 by Everett. M. Rogers in his book *The Diffusion of Innovations* (2003), who proposed there were five elements that categorised adopters within a social system; innovators, early adopters, early majority, late majority and laggards. This is an influential model is commonly displayed as a bell curve to describe the adoption characteristics of people today (*See Figure 2*). It is generally accepted that there is a gap between each successive phase in terms of the purchasing habits of customers (Cooper & Vlaskovits, 2010).

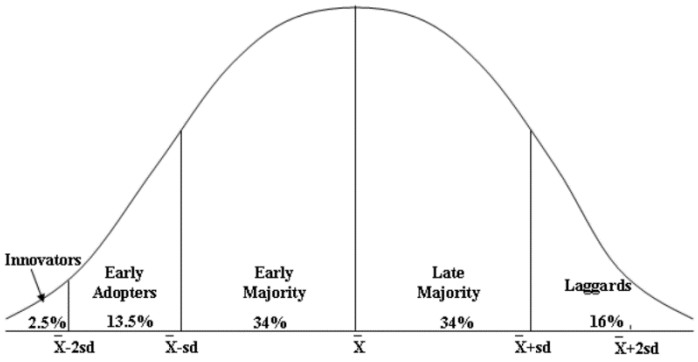

Figure 2: Adoption categorisation. (Source*: Rogers, 2003*)

While each segment divides from that which follows, the biggest gap that organisations struggle with is how to "cross the chasm" between early adopters and the early majority (*see Figure 3*).

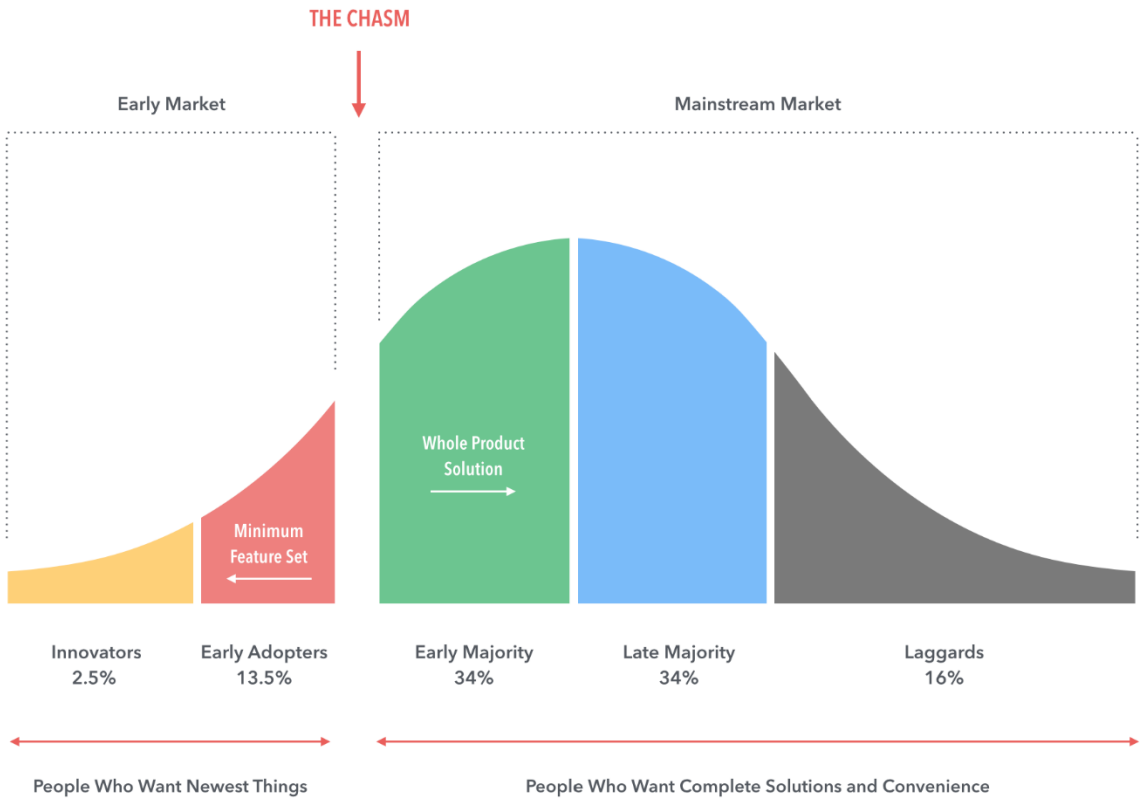

Figure 3: Crossing the Chasm. (Source: *Moore, 2014*)

Moore (2014) argues that crossing the chasm involves more than just catering for the innovators and early adopters, as these customers will limit your organsiation and often leave you when they are exposed to the next piece of new technology. While it is acknowledged that innovators and early adopters provide an exciting segment to test your offerings, Moore (2014) proposed that an organsiation can derive much more value through understanding the salient issues, problems and gain-creating features of those who sit on the right hand side of the technology curve – the late majority and the laggards who are adverse to the uptake and use of technology.

HCD has been seen as a valuable means to address the limitations evident in these technology life cycle adoption curves, including the problem of vagueness and uncertainty which can surround the development and design of software (Ruhe & The, 2004).

3.8 Introducing human centred design

HCD is an method of problem solving through a creative approach (IDEO, 2022). HCD starts with people and deep empathy and ends with solutions which are matched to their needs (IDEO, 2022). As such, opportunities in the design of products and services can be missed when the needs of the customers who will be using them have been overlooked (T. Brown & Wyatt, 2010). Even when field studies of users are conducted, they are often marred with preconceived ideas about what the end solutions and offerings should be (T. Brown & Wyatt, 2010). In response, HCD methodologies focus on systematically capturing customer needs to understand their problems and pain points and receiving feedback to validate prototyped solutions (T. Brown & Wyatt, 2010). HCD is thus not linear but rather an iterative "system of spaces" involving;

- inspiration – the problem or opportunity which instigates the pursuit for solutions from several sources,
- ideation – a process of creating, developing, testing and validating an assortment of ideas and concepts which may hint and lean towards solutions
- implementation – the step which takes the project from ideas and concepts to a marketable reality (T. Brown & Wyatt, 2010; Erzurumlu & Erzurumlu, 2015).

HCD solves problems using a creative approach which begins and ends with the customers and end-users that are going to use the products and services, carefully tailoring development to meet their needs (Ideo, 2017). HCD appreciates that human understanding and behaviour go hand in hand, that the assurance about whether or not products work as intended is of a much lesser consideration than whether or not individuals are able to seamlessly achieve what they need to do (Giacomin, 2014).

Current HCD is centred on the engagement of different techniques and tools which enable communication, interaction and empathy with the target customer, in order to establish a thorough understanding of their pains, gains and 'jobs to be done" (Giacomin, 2014). This requires immersion into the day-to-day life of prospective customers and the development of an appreciation for their contextual conditions to grow an understanding of the functions they are trying to perform (Cardoso, Gontijo, & Ono, 2017). Because the HCD process is anchored on the interests of users rather than in the designers' creative desires, it results in a

physical, perceptual, cognitive and emotionally intuitive offering based on a user perspective (Giacomin, 2014). The HCD process can be represented as a pyramid (*see Figure 4*), highlighting its hierarchical structure which works from a scientific base in human physical, perceptual, cognitive and emotional characteristics to include more complex elements about human interactions and their sociological features (Giacomin, 2014)

Figure 4: Human-centred design pyramid. (Source*: Giacomin, 2014*)

During the 1970s Gould and Lewis (1985) recommended three principles for user-centred design: (a) an early focus on users and tasks; (b) empirical measurement; and (c) iterative processes. The early focus on users and tasks relates to gaining an understanding of who the user will be and the nature of their expected job to be done. Empirical measurement commences early in the development to measure and analyse reactions to, and performance of, simulations and prototypes in addition to recorded observations (Gould & Lewis, 1985). Iterative processes allow for addressing problems and challenges in a cycle of design, test, measure and redesign as many times as necessary (Gould & Lewis, 1985). When discussing empirical measurement, Gould and Lewis (1985) were alluding to user tests rather than systems tests. In other words, prototypes were intended to test and assess how *useable* they are. When testing prototypes, Gould and Lewis (1985) suggested that observations are recorded and analysed in regard to thoughts, performance and attitudes. Gould and Lewis (1985) expanded their recommendation on iterative design to as a means of behavioural testing and incorporate improvements into the next version. They emphasised that iterative

design should not be a matter of "if time permits, we will iterate," as this is not satisfactory or appropriate as a design philosophy (1985). Gould and Lewis (1985) also expressed that iteration is not a platform to be sloppy in design and nor should it be ignored to save time in the overall process of design.

3.9 Design thinking

Design thinking is process which uses an HCD approach to innovation. It is an iterative approach for identifying and developing innovative solutions to complex problems through the deliberate incorporation of human interests and concerns in the design process (Brown, 2008; Geissdoerfer, Bocken, & Hultink, 2016). Design thinking can be described as a management tool and an organisational resource which can overcome some of the entrenched over-dependence on traditional analysis (Kimbell, 2011). Design thinking has also been described as a management concept as a result of exploring and working with innovation. This is gaining popularity in both consultancy projects and executive education with its application being seen in a variety of industry contexts (Rauth, Carlgren, & Elmquist, 2015).

Design thinking is not new when we look at its individual disciplines and attributes. However, what is new is how these attributes are coordinated under a systematic design thinking umbrella (Beckman & Barry, 2007; Rauth et al., 2015). The design rationale began to come to the fore in the 1960s, when it was realised that embedding innovation into organisations required trial and error work spanning many disciplines, and that this joining up meant that the first issue was to develop a clear picture of the problems that needed to be solved (Beckman & Barry, 2007; Kimbell, 2011). Based on these terms, design thinking is a dynamic and far-reaching problem framing and solving activity which goes hand in hand with solution development, as opposed to a process conducted in chronologically sequential stages. This emphasis on iteration also has the benefit of protecting the process from paralysis through analysis (Kimbell, 2011; Meyer, 2015).

Design thinking has become very popular in the since 2012 by way of the business presses, which have produced numerous management books and specialised publications in the likes of the *Harvard Business Review, The Economist, Business Week, The New York Times* and *The*

*Wall Street Journal. A*lthough generally understood in common terms, a single accepted definition of design thinking is yet to emerge (Liedtka, 2015; Meyer, 2015). This could be due to the longstanding impact of existing terminologies such as product design, innovation and marketing, which has had a well embedded history in the literature and many mind-sets (Liedtka, 2015).

The increasing interest in design thinking has led to an increasing demand for a conclusive definition and a toolbox of techniques (Dorst, 2011). However, the design community has been reluctant to provide a simplified definition and framework, highlighting that it is the many perspectives and approaches that make the field the rich and flexible framework that it is (Dorst, 2011). Buchanan (2001) for example, argues that one of the strengths of design is its lack of a single definition, even though this has created a great deal of unproductive dispute and misunderstanding. Buchanan (2001) highlights the importance of individual creativity, which means that individuals have definitions of design which are as varied and distinct as they are from each other. Regardless of the descriptive or formal definition of design, what it does present is useful research hypotheses which can guide the gathering and investigation of relevant causes which so enlightens and informs consequent inquiry (Buchanan, 2001).

Kimbell (2012) provides two interesting early design thinking definitions, one being form based and the other more abstract; Alexander's 1971 definition claimed that design objects have a lot to do with their physical form, a meaning that still resonates with many designers. While on the other hand, Herbert Simon's 1969 definition discusses design as being more aligned to organisations and as made up of a distinctive blend of science and ill-defined problems (Kimbell, 2012). Buchanan (1992) conceived that design is also concerned with activities and organised services which takes into account the human aspect.

There is often confusion about design thinking due to the often quite different modes in which it operates. For instance, industrial designers think in terms of possibilities, while engineers are concerned with what is necessary and marketers concentrate on the contingent attitudes and preferences of customers and end-users (Buchanan, 1992). Though design thinking often touches industrial, engineering and marketing design, as a specific field it goes a step further by consciously using a deeper and integrated viewpoint which is anchored in the human experience element (Buchanan, 1992). It is often found that technology is thought

about in terms of its product, such as machines, rather than as an arrangement of disciplined systematic thinking that is attached to human activity, circumstances and needs (Buchanan, 1992). Design thinking helps to orientate technology planning and development toward the interplay which occurs between the human elements of signs, things, actions and thoughts and the technology itself (Buchanan, 1992; Kimbell, 2011).

The above explains what HCD and design thinking is, but further explanation is needed to understand what HCD could offer to FarmIQ over and above the approach which they had taken.

3.10 What design thinking and HCD offers

Problem identification and problem solving are central to design thinking. As a method, design thinking offers the opportunity to tap into designers' capacity to overcome the limits of traditional problem- solving (T. Brown & Wyatt, 2010). It does this through the social and creative manner in which insights and observations are gathered and deployed and the way these insights and observations are decoded and recoded to arrive at user-centred meanings and a collective starting point (Beckman & Barry, 2007; Brassett & O'Reilly, 2015).

HCD assumes that all current problems are ill defined (Kimbell, 2011). Quality time and resourcing must be applied to redefining, understanding and framing the problem to be solved, as this creates a platform for better solution concepts and overall results (Dorst & Cross, 2001). Hence the design process begins with establishing the problem or problems that are worth solving. One of the challenges facing the use of HCD in an established organisation is the need to recognise that, in the early conceptual stages, time must be spent redefining the problem and that there may be changes to this understanding as the project progresses (Dorst, 2006; Kimbell, 2011). HCD has been described as dealing with wicked problems for this reason through integrating human experiences and influences (Buchanan, 1992; Eneberg & Holm, 2015).

"Wicked" is a term used to describe hard to solve problems that are incomplete and that have many, diverse related interests, such as stakeholder views and variables. Such problems are thus constantly changing; solving one part of a problem can often result in creating other

problems (Leinonen & Durall, 2014). Wicked problems have either good or bad solutions rather than right or wrong answers and such problems frequently emerge in areas which involve technology (Leinonen & Durall, 2014). An illustration of this is the communication tensions which can be encountered between design thinkers and scientists with specialised skill sets (Buchanan, 1992). This can manifest as persistent communication challenges due to the non-linear and evolving nature of design thinking methodology.

In Peter Rowe's book *Design Thinking*, an early discussion about design thinking is discussed, which considers that solutions are shaped through a problem-solving process (Rowe,1998 cited in Kimbell, 2012). Kimbell goes on to discuss how design thinking is capable of dealing with ill-defined problems, framing problems, the co-evolution of problems and solutions (2012). Designers use the formation of some sort of quasi subject, idea or hypothesis in relation to the problem which is tested to measure potential future success and to provide a framework for further exploration (Buchanan, 1992). This is the challenge of the design thinker – to try to conceive and plan for what doesn't yet exist (Buchanan, 1992).

Buchanan (2001) identified design as a method which when unlocked from art schools, would better serve the purpose of broadening knowledge and addressing increasingly complex problems in a wider and more humanistic manner, over and above entrenched and traditional models of research.

Observation is an important element in defining the initial opportunities and problems based on a user focus, often referred to as "needfinding" (Seidel & Fixson, 2013). Needfinding is an ethnographic approach which has been useful to gather insights and deep understanding of different experiences that the end-user may encounter and has served as a useful tool to create an empathetic and clarified set of needs for the benefit of the design team (Seidel & Fixson, 2013).

Design thinking has a knack of being able to cross boundaries and keep pace with the fluid nature of business and business environments in a manner that traditional business school methodology cannot (Kimbell, 2011). The process of design thinking provides benefits for both supply and demand sides. The supply side may enjoy better returns through favourable economies of scale, gathering information and experience, learning by doing and interrelating

technology with the end-user; while the demand side benefits from having a tailored product or service best suited to their needs (Safarzynska & van den Bergh, 2010). Irrespective of whether or not innovation is led by supply or demand, the interactions between producers and users is an important relationship with both playing an equally important role during both the innovation and subsequent phases of product development (Malerba, 2007). These interactions provide valuable learning. To ensure that the learning collected through feedback and insight can asisst with market adoption, however, the interactions are best done directly between producers and targeted end users (Safarzynska & van den Bergh, 2010).

The development of technology niches are an example of using design thinking in developing and rolling out technology and innovation. This is through the process of experimentation, learning and improving in an interative manner (Lopolito, Morone, & Taylor, 2013).

The literature has shown that design thinking provides business opportunities. The next section extends this by discussing how design thinking can be used to identify hidden opportunities.

3.11 Finding hidden opportuntites

Henry Ford famously said that if he had asked his customers what they wanted, they would have said “a faster horse”. This example illustrates that customers cannot express their unmet needs fully, which can create a critical knowledge gap in creating customer satisfaction (Brown and Waytt, 2010) . When customers cannot express their needs fully, they are called latent needs (Van Auken, 2016). Understanding the customers latent needs creates assists commercial success, therefore being able to identify them is a critical task (L Carlgren, 2013).

The identification of latent needs can be achieved through co-creation. The process of co-creating technology-enabled value propositions, is best done when the exchange processes of the service provider and the customer are examined to better understand their exchange patterns and interplays (Breidbach & Maglio, 2016). By focussing on value propositions which are centred on customer and end-user JTBD, the interconnectedness between the two can be better understood so that the result is one that is more likely to be successfully marketed (Hankammer, Brenk, Fabry, Nordemann, & Piller, 2019). This hinges on the ability of the

design thinking team and the service provider to empathetically experience the context of the customer and end-user's reality to understand their unmet, and often latent, needs (Breidbach & Maglio, 2016). The actionable element in the quest to successfully create value, is through the establishment of the JTBD which removes the constraints of an output focus (Bettencourt et al., 2014).

The co-creative nature of design thinking also helps to unbundle siloed and vertical structures within organisations (Day & Schoemaker, 2016). It also requires a strong suite of relational capability within the organisation, and personnel, partners and agents who be successfully accessed and engaged in the process (Day & Schoemaker, 2016).

There are substantial opportunities for managers and decision makers who wish to progress their innovative abilities through the unlocking process that co-creation offers, by building a picture of the customer's perspective and building strong associations through enhanced relationships between all parties involved in the process. (Frow, Nenonen, Payne, & Storbacka, 2015). Terms such as "co-creation", "co-design" and "user centric" are beginning to gain popularity as businesses aim to offer new meanings for their offerings, markets and value propositions through engagement with customers (Kimbell, 2011).

One of the important outcomes from a customer JTBD and design thinking process, is the construction and orientation of the organisation's common understanding on what is significant and important to the customer and end-user, and then focussing the resources and energy of the organisation to align to that (Bettencourt et al., 2014). It must be remembered that it is the customer who co-creates value.

The above has introduced the benefit of finding hidden opportunities through design thinking and reinforces the importance of the setting in which successful design thinking occurs. There is also a reminder about the important focus on the end user. This will now be developed further in a discussion about the practical elements of using design thinking.

3.12 Using design thinking

For those taking part in a design thinking project for the first time, it is not uncommon to feel overwhelmed by the fuzzy and chaotic environment compared to milestone-based projects (Brown & Wyatt, 2010). The introduction of new concepts into organisations is often accompanied with feelings of fear and uncertainty, generated through an absence of understanding about how the new concept will affect individuals and the firm itself (Rauth et al., 2015). However, reflections over the life of a project often see team members coming to appreciate the logic of the methodology and the value of the results achieved (Brown & Wyatt, 2010) .

Based on work in the 1970s, Gould and Lewis (1985) were adamant that at the outset of any design process, design teams are user driven and that the focus remained on *understanding* users via direct contact rather than on "identifying, describing, stereotyping or ascertaining" them. They further recommended that these users were *typical* users, not grouped varieties of experts, and that they were not used simply for a post hoc analysis of design outputs. Gould and Lewis (1985) went on to say that such post hoc user input lost the opportunity to gather knowledge and insights through the process of building an understanding of the physical and emotional characteristics of the user's day-to-day world. Therefore, the temptation to avoid difficult feedback and thus the opportunity to make changes, is not advised.

When considering innovation processes, designers begin by building a robust understanding of both group and individual customers' user needs. This is achieved through ethnographic research to form a deep appreciation of their relevant context (Beckman and Barry, 2007). Ethnography is a research methodology which is often used in sociology and is used to study and understand the different interactions between people in terms of culture, human behaviour and social relations (Stickdorn & Schneider, 2011). Design ethnography involves the facilitation of conversations between designers, users and clients as part of a process to design, validate and produce services and products (Stickdorn & Schneider, 2011). Ethnographies are important as we move from a mass marketing approach towards offerings tailored to more precisely defined customer and end-user segments (Beckman & Barry, 2007). Therefore, it is impossible to separate design thinking from ethnography in some form.

Once initial insights have been gathered, the next step is to build an initial framework by processing the information gathered and identifying what is missing (Beckman & Barry, 2007). This may result in reframing or developing new stories that work out new angles to view the problem and create the possibility of new visions for potential solutions (Beckman & Barry 2007). This is a very different process from more conventional innovation, which simply used to "take place" in a largely unstructured fashion (Beckman & Barry, 2007). From framing and reframing, the process moves into value proposition development by synthesizing to test the concepts, features and ideas that have been established to provide benefits and solve problems for the target customer and user segments (Beckman & Barry, 2007).

Solutions are generated by identifying the best matches to customer requirements, which are tested with to produce further improvements and on this basis to identify which solutions to take forward (Beckman & Barry, 2007). Prototype concepts are generated in a crude fashion. They are used to instigate useful feedback and information, identify where improvements can be made and to examine how potential customers and users interact with them – this is an experimentation and learning exercise (T. Brown & Wyatt, 2010). Taken as a whole, innovation unfolds as a complex process involving problem finding, problem selection, solution finding and solution selecting. Each step has value and should involve the sustained engagement of participants for a period of time. It is worthy to mention that the innovation system and process described is likely to require improvisation (Beckman & Barry, 2007).

The core principles of design thinking in large organisations are: *focus on the user, challenge the problem, include diverse viewpoints, make tangible* and *experiment* (Lisa Carlgren, Elmquist, & Rauth, 2014; Rauth et al., 2015). This approach recognises that design thinking provides the opportunity create interaction which is easy, empathetic and intuitive between people and systems, technology, products and services within the context of the end user (Meyer, 2015).

The above has discussed practical elements of using design thinking. To this end, it is necessary to introduce the tools of design thinking.

3.13 Design thinking tools

To bring design thinking models to life, there are a variety of design thinking tools which can be applied. The tools in this chapter are a blend of guiding principles and artefacts.

Empathy

A very important principle in design thinking is empathy. Through the development of empathetic mind-sets and attitudes, advances occur which bridge the gap between customer-centred innovation and good design (Carmel-Gilfilen & Portillo, 2016). For this reason, empathy is an essential element in any HCD process (Buchanan, 1992). Empathy also imposes a human element in design, taking customers from being mere end-users, to being personas with experiences, feelings, thoughts, problems, needs and opportunities (Carmel-Gilfilen & Portillo, 2016). Empathy helps to transform and focus energy from a marketing and production based system to a value creation based, and people centric system (Bettencourt et al., 2014). Therefore, the value impact created through empathy is twofold; it has implications for the customer by providing them with something that they really want, which flows directly into becoming a success element for the organisation itself.

The exercise of collecting and analysing deep customer insights is soundly based on the theoretical understanding that HCD offers to identifying problems and then both refining and solving them using empathy as an approach (Beckman & Barry, 2007; Price & Wrigley, 2015). It has been suggested that empathy cannot be realised fully in the absence of affective capability or the ability to imagine how other people feel, think or behave if they were to be in the place of another (Hess & Fila, 2016). Many companies fail when they and their employees take an unempathetic approach to design, as this means that customer needs often go unsatisfied (Iglesias, Markovic, & Rialp, 2019). Questions such as “what can we sell customers and what can we make from them?” deprive the organisation of valuable input which can effectively deliver firms with rich and valuable information such as defining the problem and delivering valuable feedback during development stages (Price & Wrigley, 2015).

The classical methods entailing user surveys and focus groups rarely capture important insights (Brown and Wyatt, 2010). The data gathered are often too aggregated to gather true insights about end-users. In addition to surveys and focus groups, groups of informed

customers are often investigated, but this is constrained by what such customers can explicitly express or are biased by their peculiarities (Eppler & Kernbach, 2016). It is only through the introduction of more empathetic tools that insights are gathered about day –to-day enhancements over and above the familiar and such insights are more likely to occur when explored within in the environment of the end-users themselves (Leonard & Rayport, 1997). This approach serves not only to gather insights based on the expressed information, but also identifies insights about the latent needs of a customer, which arguably is where many previously unrecognised unsolved problems and JTBD can be found (Carlgren, 2013). Additionally, by being present in the customer's natural environment and context, the design process is able to probe beyond the constraints of expressed information and capture many valuable non-verbal clues about current and future needs (Carmel-Gilfilen & Portillo, 2016).

Modes of thinking

A person's mind is quite prone to repeating the things that it is used to and though this is somewhat useful for design purposes, it is also an inhibitor of creativity (Müller-Wienbergen, Müller, Seidel, & Becker, 2011). The same sentiment is echoed Brown and Katz's book *Change by design* (2009), which encourages designers to diverge by creating many choices so that consumer behaviour, innovation ideas and insights are considered more widely before converging and making choices. One tool which is useful to extend creativity is divergent and convergent thinking, which helps to get designers off the beaten track and extend knowledge (Müller-Wienbergen et al., 2011).

Divergent and convergent thinking is a mode of thinking is a key part of the creative process, and provides the means to explore many diverse directions (Vries & Lubart, 2019). Divergent thinking is a creative thought process, whereas convergent thinking can be used as a logic thought process to arrive at a single best response (Vries & Lubart, 2019). Designers use both divergent and convergent thinking – the generation of information, ideas and insights through the divergent processes and the ability to focus attention and make decisions through convergent processes (Basadur, 1995; Goldschmidt, 2016). Divergent and convergent thinking has also been used to support and promote the lateral and vertical revolutions of thinking needed to identify and address problems which range from abstract and vague to precise and concrete (Goel, 2014). It is through both systems of thinking that design is

positively supported. Too much creativity on its own intensifies vagueness while a lack of choice or breadth of consideration in problem finding is equally restrictive (Goel, 2014). Design thinking has developed various visual tools to facilitate divergent and convergent thinking (Eppler & Kernbach, 2016).

There are four reasoning techniques which can be applied in design thinking. They are, abductive, inductive, deductive and analytical reasoning. In design thinking, abductive reasoning is used initially. Such reasoning differs from deductive and inductive thinking, in that inferences and guesswork are based on what we see and observe now, not on past or old data, which is then used to create ideas and find the most satisfactory solution to often ill-defined problems (Kimbell, 2011; Meyer, 2015). *Table 2* illustrates how abductive, inductive and deductive thinking are used. This shows that all three types of reasoning are important. Deductive reasoning is used to predict consequences of ideas while inductive reasoning is used to test proposed solutions, forming a problem-solving cycle that generates data which are then fed back into the abductive reasoning process once more (Meyer, 2015). Roger Martin (2009), explained that he sees a combination of abductive, inductive and deductive reasoning in design thinking. This combination assists organisations to generate new breakthrough concepts by shifting away from merely choosing between existing alternatives (Kimbell, 2011). Bauer and Eagan (2008) felt that analytical thinking addresses matters such as being realistic about capital, which when combined with the design thinking, provides the grounds and knowledge and creativity.

Table 2: Application of inductive, deductive and abductive thinking. (Source*: Meyer, 2015*).

Pains and gains

An important task within design thinking projects is to identify the pains and gains for customers and end-user experiences (Buchanan, 1992; Kimbell, 2011). When used in relation to design thinking, pains and gains is a term which is used in the profiling process of customers (A. Osterwalder et al., 2014). Customer pains and gains are evidenced based and collected through customer involvement to avoid the pitfalls of researcher bias (Price & Wrigley, 2015).

Customer pains are descriptions of anything which obstructs or prevents the customer from getting their "job done", including risks, obstacles and frustrations, while customer gains are descriptions of the achievements, benefits and favourable outcomes that customers want, whether they are required, expected, desired or unexpected (A. Osterwalder et al., 2014; Alexander Osterwalder, Pigneur, & Clark, 2010).

It is important to identify and highlight the most relevant pains and gains as these create the best solutions for the customer and end-user in relation to their JTBD (A. Osterwalder et al., 2014).

Job to be done

To solve a problem or create an opportunity for customers or potential customers in any given situation, it is beneficial to understand their JTBD (Christensen, Anthony, Berstell & Nitterhouse, 2007). Customer jobs are the tasks and activities that customers are trying to carry out (A. Osterwalder et al., 2014; Ulwick, 2005). JTBD is used to inform organisations' analysis and understanding of customer behaviour and what *causes* them to behave in that manner (Christensen, et al., 2016). Through the lens of the customer JTBD, organisations are able to avoid the trappings of being static and in the absence of understanding the JTBD, organisations tend to be deprived of really understanding buying behaviour (Christensen et al., 2007). The innovation opportunity lies in being able to identify poorly done "jobs" that effect customers or end-users and then designing a better suite of products, services or experiences to assist performing "jobs" easier and/or better (Christensen et al., 2016).

Building an understanding of the circumstances in constructing a picture of customers' JTBD is more important than defining different technologies or trends, customer characteristics and product attributes (Christensen et al., 2016), which highlights the importance of the powerful emotional and social dimensions within the context of the customer.

Story and Journey mapping

Story mapping is an active process and is designed to understand the processes that stakeholders and potential customers use to reveal and appreciate where real value can be created for them (Cleland-Huang, 2015; Rosenbaum, Otalora, & Ramírez, 2017; van der Veen & van Ossenbruggen, 2015). Customer journey mapping (CJM) is a reasonably simple and yet valuable visual tool which links the insights gathered through empathy processes into an actual sequence of touch points and prompts that users go through to finish a job (Marquez, Downey, & Clement, 2015; Rosenbaum et al., 2017; Tschimmel, 2012).

The CJM is a physical object usually constructed on a large sheet of paper which is divided into three basic sections. The left hand vertical side of the map usually contains prompts and touch points, the horizontal section at the top of the map highlights the various stages that customers would experience and the middle section is where the actual journey is recorded (Marquez et al., 2015). This creates a matrix in the remainder of the area where information about the customer is attached. Due to the flexibility of CJMs, they can be used successfully to

examine various channels and scrutinize movements involving space, time, with market or environmental prompts or an event as examples (Marquez et al., 2015).

As with many academic design thinking related articles which tend to both admire and prescribe benefits, there is a risk that managers implementing CJM's can be confused about how to use them (Rosenbaum et al., 2017). The risk is that inexperienced managers may take a somewhat unpragmatic view of their organisation in terms of overestimating the satisfaction of customer's current experiences, which increases the risk of failing to find where and what problems are worthy of further investigation; in this instance, a bottom up approach is recommended (Moon, Han, Chun, & Hong, 2016).

Value creation

The concept of value in design thinking processes appreciates that exchange and relationship-based value has a dynamic nature which is influenced by the perceptions, needs and environments of different actors, whether they be designers or end-users (O'Cass & Ngo, 2011). A good fit of value creation is created when what an organisation perceives as important, and what the end-user perceives as important are the same thing (O'Cass & Ngo, 2011; A. Osterwalder et al., 2014; Prahalad & Ramaswamy, 2004). Tools such as the value proposition design canvas assist this process by being able to match a clarify and understand customer profile in contrast with a value map (A. Osterwalder et al., 2014). The value mapping process of establishing a good customer and value fit requires an iterative approach (A. Osterwalder et al., 2014).

Personas

Personas are used to display and prototype solution concepts in relation to summary condensations of insights and information about end-users (Putnam et al., 2016). Personas are hypothetical archetypes based on end-users. They are particularly useful in co-creation processes for differentiating the multiple JTBD for end-users into sensible and more specialised groups and on this basis to inform decision making processes and to guide the gathering of further insights (Bornet & Brangier, 2016; Putnam et al., 2016; Viana & Robert, 2016). Bornet and Brangier (2016) add that not only do personas serve to provide an analysis tool, they also provide a platform for building empathy.

Personas enable the designer to push beyond demographic information to characterise quasi real users by means of a name or title, personality, attributes and a JTBD. Such personas serve three main objectives:

1. To model the end-user in a summarised manner
2. To communicate within design teams and with end-users
3. To guide decisions about end-users' future requirements based on the most suitable identified needs (Bornet & Brangier, 2016).

Viana and Robert (2016) argue that personas give anonymous and ethnographic data about end-users a "human face", and through doing so help to ensure that design teams remain focussed on the end-user and their relevant context and needs.

Prototyping

Rapid prototyping helps to define and refine the concepts that design teams create. It assists what would otherwise be extremely complex design decisions (Day & Schoemaker, 2016). Day and Schoemaker (2016) report that rapid prototyping is more successful when:

- an experimental mindset exists;
- there is a readiness to potentially change existing offerings and held beliefs;
- the participants in the rapid prototyping process can collate and share any insights;
- the organisation is willing to search and probe beyond their existing boundaries;
- the organisation is comfortable with failure, which increases the propensity to learn and improve.

Rapid prototyping is designed to consciously go through trials and errors so that learnings can be gleaned and applied to further versions (Liedtka, 2011). The initial prototypes are suggested to be in a very low-resolution format. This has several benefits, including encouragement of the target audience to interact with the prototype and offer insights for improvements (Leinonen & Durall, 2014). Low resolution prototypes suggest to end-users that there is a willingness to make improvements and require minimal resources to construct (Leinonen & Durall, 2014). This ensures that there is not a large amount of time or money invested in the concept, lessening the danger of cementing and restricting ideas about further improvements. When organisations are comfortable with failure, they create an opportunity and culture that is able to learn and improve in an agile and cost-effective manner (Day & Schoemaker, 2016)

The principles and tools described above are used collectively in HCD. They form an essential element in the interaction between the actors and teams participating in HCD.

3.14 Design thinking teams

It is suggested that design thinking takes place within a team, and that the team is made up from personnel who have a mixture of learning styles and capability (Beckman & Barry, 2007). Teamwork has been linked to harnessing creativity, along with breakthrough innovation as opposed to working individually and in isolation (Callaghan, 2009).

Teams working on innovation are advised to bear in mind that the allocation of time and effort should involve an iterative and fluid movement between theoretical and real life/practice realms, or in other words analysis and synthesis, which removes the risk of becoming entrenched in one or the other (Beckman & Barry, 2007). It is not through study but through practice that designers become masters and through this type of understanding and reflective practice, first-hand knowledge is attained (Meyer, 2015).

Though there are numerous possible benefits from having teams made up of diverse members, it is also beneficial to be aware of how effective communication is affected by functional diversity. Such diversity may create team challenges and conflict (Pelled, Eisenhardt, & Xin, 1999; Seidel & Fixson, 2013). However, there are challenges too in design thinking and it is prudent to be aware of how to identify them.

3.15 Conclusion

This chapter has explored the literature on business planning, understanding the world of customers and technology in agriculture. This encompassed the farmer decision making, the development of software and technology adoption. Then HCD and design thinking were discussed at length. The discussion on HCD and design thinking has outlined the characteristics of classic business development and customer segmentation and then the characteristics of HCD and design thinking. However, it is not all smooth sailing as there are challenges and some of them are important. These will be discussed in Chapter 5.

Chapter 4: Methods

4.1 Introduction

The previous chapter outlined the general principles of human centred design (HCD), including a summary overview of the sorts of tools typically used by its practitioners. As this suggests, HCD is itself a cluster of methods. It is important to appreciate, however, that there is no set recipe for undertaking HCD. HCD methods are bespoke - the tools put to use are selected according to the needs of the project and its participants. HCD is not a paternalistic black box, nor a prescriptive solution. Accordingly, this chapter focuses on the specific method sequence used by the HCD project team in the case of FarmIQ, detailing who was involved and what they did.

As explained in Chapter 1, this thesis is a piece of action research – I acted both as a participant in the HCD team and as a researcher collecting information on the design process as it developed through its many iterations. While participating, I systematically made observations, held conversations and took fieldnotes of the interactions taking place. I also collected various artefacts, taking photographs of different activities to collect data and insight for analysis. This allowed the process to be recorded and reconstructed, ensuring that it was not lost in the flow of its undertaking. The results of this research travelled simultaneously in two directions. On the one hand, they were used within the HCD process itself, contributing to its ongoing sense-making, while on the other hand they also underpin this thesis, its reconstruction of and reflection on how this process worked.

To create flow for the reader, this chapter reconstructs the design process at FarmIQ in narrative form. I begin by framing the scene, with introductions of the participants and the settings in which they interacted. I then outline the four distinct phases of work, introducing the specific tools used when they arise. The following chapter presents the results of this work, echoing the narrative structure used here.

4.2 The research setting, participants and project phases

The FarmIQ HCD project ran from October 2015 to June 2016. Other than myself, there were three key sorts of participant: farmers, an HCD facilitator and FarmIQ staff. There were also research assistants, who together with the HCD facilitator, the FarmIQ staff and I comprised the design team.

Prior to data collection, a human ethics application was submitted to Massey University. The project was evaluated by peer review and judged to be low risk. Consequently, it was not revied by one of the Universities Human Ethics Committees. As the named researcher, I was made responsible for the ethical conduct of this research. This ethics approval was granted on 28 January, 2015, and was valid for a maximum period of three years.

During the project, this design team engaged with farmers as end users in the Manawatu and Mid-Canterbury districts. Farmers participated in a range of different ways across the opening phases of the project. Ten farmers were involved initially in eight deep dive interviews undertaken during the first phase, when raw, farmer-centric data was collected. A letter was sent to all farmers in the first phase which detailed the purpose of the research, the human centred design approach being taken, the commitment being requested from farmers and the ethical requirements of anonymity of all participants in all data collection and the subsequent reporting. In the second phase, 37 farmers attended two workshops to validate our design-led farmer personas and solution concepts. The farmers in the second phase were made aware at the beginning of these two workshops that we would be collecting data for subsequent analysis and that their identity responses within the workshop would be fully anonymised. The farmers were found using a combination of utilising connector networks, snowballing techniques and personal connections. None of the farmers were FarmIQ clients. The farmers in both phases were a mixture of farming couples, farm owners, managers, employees and future farm owners. There was diversity in their farming systems, which included sheep and beef, dairy, mixed cropping, lamb finishing and bull beef. There was also diversity in the length of time that farmers had been farming, from very early in their farming career to near retirement. All farmers were given the opportunity to opt in or out of the research.

The project commenced in mid-October 2015. At this point, the facilitator was appointed. Semi structured, deep dive empathy interviews were used for collecting raw data and insights from farmers. The practice of empathy was used as a means of ensuring that farmer centricity was met and maintained at all times. The importance of empathy was highlighted in ongoing team discussions which established shared protocols around deep listening, reserving judgement and learning about the farmer world through the capture of expressed and latent needs. Focus groups were not favoured due to their tendency to supress empathy and to side-line the observation of important non-verbal clues.

The raw interview data and field notes were analysed by the facilitator and myself to search for thematic unity and patterns to identify a quasi-problem that FarmIQ needed to solve. This information was used to create a HCD project scope and design brief that was signed off by FarmIQ in November 2015.

The HCD facilitator had the pivotal task of managing and guiding the HCD process and its participants. As a member of the team, I assisted the facilitator while also undertaking the research for this thesis. In my researcher role, I captured a range of data about both the process itself and the participants. I was interested in particular in learning about how an organisation and a team of staff adjusted to and engaged with the HCD process. Eight staff from FarmIQ participated in the project. There were two North Island and two South Island regional sales managers, along with two Wellington-based office staff, a training and support manager and a senior marketing manager. These four staff participated in farmer interviews, data analysis and farmer workshops using the HCD tools and methods. The CEO and a senior software developer from the Wellington Head Office participated in the first workshop on the first day and during key concept testing stages in subsequent workshops. Late in the project, a Chief of Operations was appointed to FarmIQ, and he participated in the fourth phase of this project, when the final deliverables were developed.

As the above suggests, the project divided into four distinct phases. These phases correspond to the distinction between convergent and divergent modes of thinking discussed in the previous chapter. Taken as a sequence, the project's four phases can be visually represented as a "double diamond", as suggested by the British Design Council (see *Figure 5*).

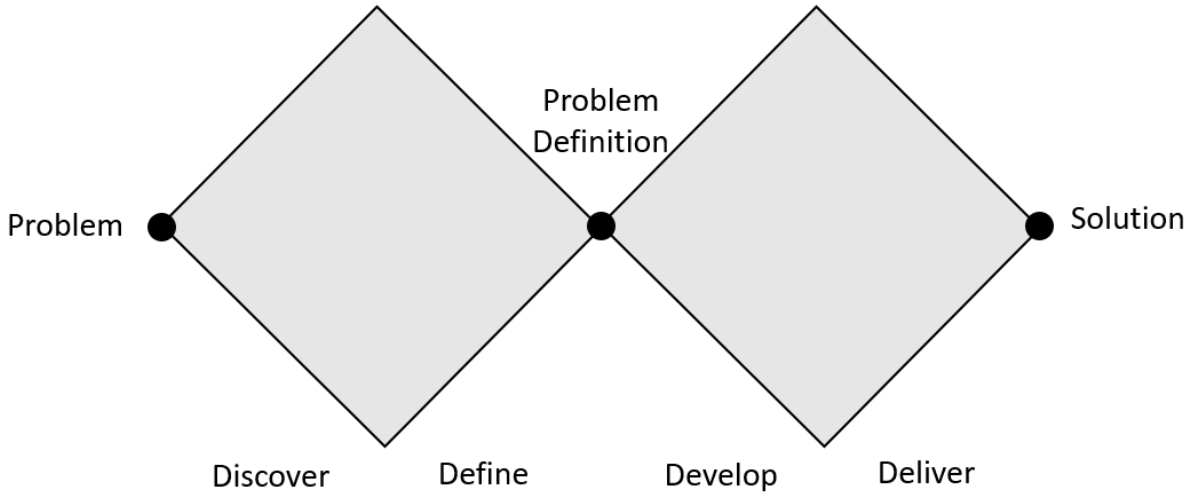

Figure 5: The British Design Council Double Diamond. (Source: *Stickdorn & Schneider, 2011*).

The double diamond clearly separates the problem and solution phases, with each given equal emphasis. This shared emphasis counters the tendency of innovators to produce solutions that lack grounding in a clear understanding of the problem itself. Phase one focuses on a divergent opening up of problem (discovery), phase two on its convergent narrowing (definition). The two solution phases follow the same logic, with divergent development activities followed by a convergent focus on delivery. Many of the design tools were used multiple times throughout the project's various stages. To simplify matters, the following reconstruction of the FarmIQ HCD process is organised by the 4 phases, with the specific tools used introduced when relevant.

As outlined in the general terms in Chapter 3, HCD involves a number of design thinking principles and tools in order to empathetically reconstruct and address the end users pains, gains and JTBD's. In practice, the engagement of these principles and tools organised the FarmIQ project into four key phases of work. The actual methods used in each phase are described in the remainder of this chapter commencing with a description of the set-up processes that were undertaken prior to data collection.

4.3 Phase 1 – problem discovery

This phase of work commenced in early November 2015. It was decided to run two three-day workshops in two locations in New Zealand, one in the North Island and one in the South Island. There were three tasks to complete prior to the two workshops. These were selecting two locations, two venues and approaching farmers to be involved. The Manawatu and Mid-Canterbury were the two selected locations. Once this was decided, venues were selected in a central site within each location. As part of the venue selection process, emphasis was placed on having a large amount of wall space. Suitable venues were found at the Massey University campus in the North Island and Methven in the South Island. At the same time, I was finding farmers for four deep dive empathy interviews in each location. Introductory information which was collected from each of the farmers who agreed to participate at this time.

The first workshop was in the Manawatu from 30 November 2015 to 2 December 2015. The second workshop was in Mid Canterbury from 14 December 2015 to 16 December 2015. Both of these workshops ran over three consecutive days.

The remainder of this chapter will describe these two three-day workshops. Both workshops followed the same process with the exception of the interviewer training on the first day of the first workshop. This first phase uses processes to produce a customer empathy map and a customer journey map for each farmer.

One the first day of the workshop, four FarmIQ staff and four non-FarmIQ staff convened at the workshop venue. At this point, a FarmIQ staff member was paired with a non-FarmIQ staff member to create four two-person interview teams. The four interview teams worked together for the three days. The next paragraph will explain the interviewer training process.

The HCD facilitator conducted the interviewer training with the four interview teams. This was a fast-paced end to end HCD exercise at the workshop venue. This was called the Wallet Project which is an immersive exercise used to train participants through the complete cycle of the design thinking process. (Stanford University d.School, N.D). One of its critical aims is to highlight the fundamental values of HCD, particularly in empathy interviewing. The reason that this exercise is selected is because of its effectiveness in engaging each team and creating high quality, experiential learning through being actively involved rather than listening to a

“talking head” (Stanford University d.School, N.D). This facilitated process allowed the interview teams to create conversations and promote reflection which encouraged the participants themselves to extract important and meaningful learning and HCD experience (Stanford University d.School, N.D). One of the other benefits is the healthy debate which occurs in a social setting (Stanford University d.School, N.D). The Stanford University d.School (N.D) chose a wallet for this exercise as it is deemed that everyone has some sort of experience with a wallet, the context of a wallet is variable in a person’s life and that wallets are often a physical artefact which provides good starting point for wide innovation possibilities.

The focus will now return to the format which was used in both of the three-day workshops. The key HCD tools are introduced in the narrative when they are first used in the project.

On the first morning of the workshop, each of the four interview teams were allocated a farming household each.

In our large group, I socialised the introductory information about each farmer. This information included the names of farmers, farm size, system. This information was provided to enable and promote a warm start with each farmer at the initial interview through being able to understand their farmer’s high level, initial context. Each interview team concentrated on their own farmer through this first workshop phase.

Socialisation was used throughout the entire project. It was used explicitly to verbally share similar and contrasting ideas, observations, findings, “aha” moments, and insight. It was also an opportunity for a question-and-answer process in group downloads to clarify data, discover and question potential blind spots in data and to create the basis of deeper farmer understanding and insighting. Socialisation occurred between interview team members when driving to and from farmer interviews, and when transferring raw data from interviews to the various canvasses. Wider and more structured socialisation occurred when the project teams came together after interviews and during work on data organisation and sensemaking. This was prompted and moderated by the facilitator. It also ensured that team building occurred and developed. The ongoing practice of active socialisation was encouraged. It was part of the

facilitators role to ensuring that socialisation was able to occur in a psychologically safe environment.

Interview teams left at the same time for their initial deep dive interviews with their farmers and were given an estimated time to reconvene at the workshop venue. Interviews with farmers ran between one to two hours, dependent solely on the farmers' time limit and willingness to talk. The interviews were not voice recorded, however, written fieldnotes were taken of the conversations and observations made.

Interview teams reconvened at the workshop venue around lunchtime and gave a verbal download to the wider team to socialise the initial findings and insights about their farmers. This involved describing early thoughts, findings and observations. Then each interview team started constructing a customer empathy map for their farmer. The Empathy Map is a pictorial synthesis tool developed by visual thinking company XPLANE (Alexander Osterwalder et al., 2010) (see *Figure 6*).

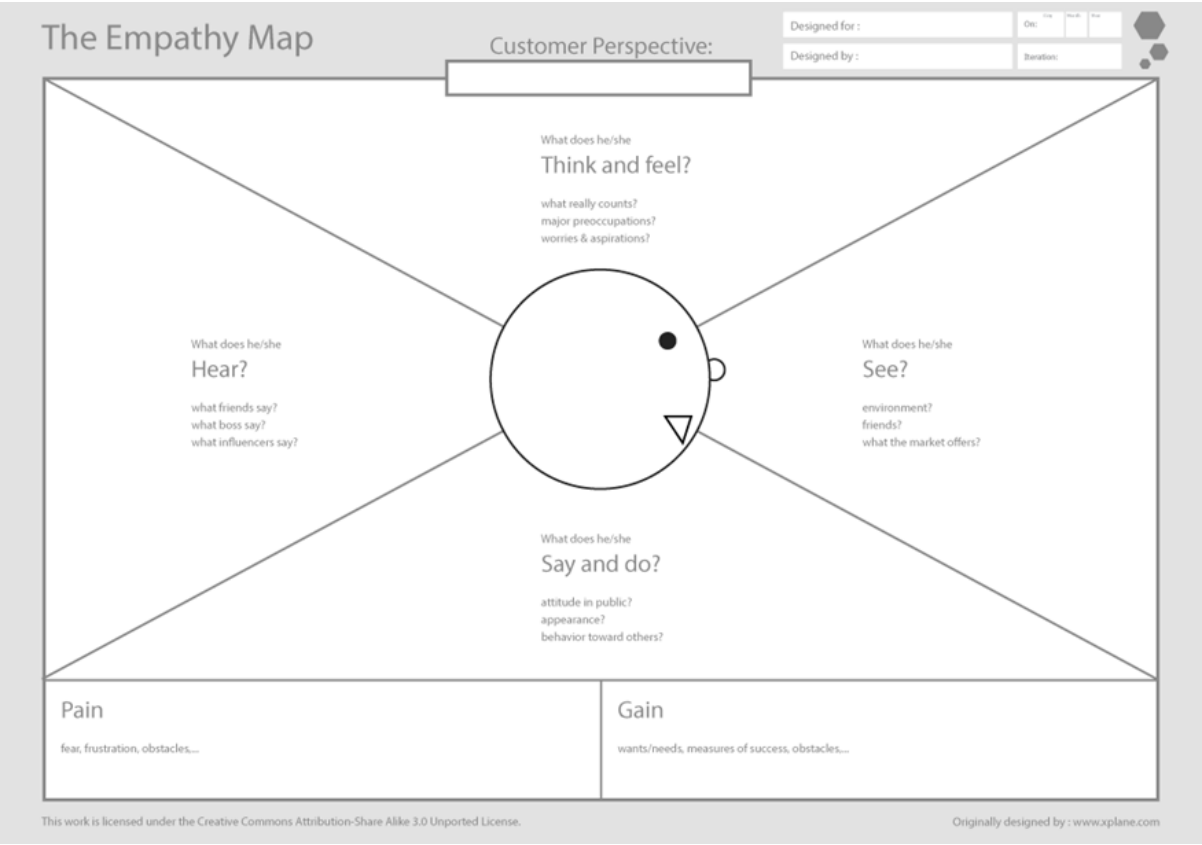

Figure 6: The empathy map. (Source: *Osterwalder et al., 2010*)

The Empathy Map is a printed canvas on an A0 sized poster. This map was used by interview pairs to collaboratively build farmer profiles after initial deep dive interviews with farmers. The interview teams used their fieldnotes and recall of information and observations to do this. This map has six questions as prompts to replicate the raw data in a visual manner to analyse and thematise the raw data. The purpose of the customer empathy map is to uncover the farmer pains and gains. The information was applied to this canvas using sticky notes.

Sticky notes are an aide that were used by interview teams throughout the entire project. They were used for writing single points of raw and analysed data with marker pens and fixing to canvasses, maps and walls. They were used because they are readily available for purchase, they are portable, and their adhesive sticky side is meant that data was moveable, removable and re-usable. They aided rapid data capture, organisation and analysis while brainstorming, experimenting, in-sighting and ideating.

After a two-hour period of each interview team working on their customer empathy map, the HCD Facilitator guided each team through a socialisation process whereby each team discussed their farmer analysis through the customer empathy map with the wider group. After this socialisation process, the interview teams continued to improve their customer empathy maps with the addition of feedback and questions from the wider interview group.

In the early afternoon, of the first day, the interview teams then used the information from the customer empathy map and their fieldnotes to create a customer journey map each for their farmers. Each customer journey map was constructed on a long piece of butchers' paper around three metres long and sticky notes. The customer journey maps were used to replicate a farmer-centric, value hypothesis based on the day-to-day farmer journey over a period of time. They were populated with raw data from their respective farmer interviews and customer empathy maps. This data were replicated onto the customer journey maps with sticky notes. The information and analysis to populate this map included expressed and latent data. These were to visualise a "farmer journey" according to different headings on a matrix. The matrix used a time sequence and relevant touchpoints and processes to order a create farmer "journey" (see *Figure 7*).

	Before	Start	During	After
Doing				
Thinking				
Feeling				
Touchpoint				
Pain point				
Opportunity				

Figure 7: Version of a customer journey map. (Adapted from: *Shridharan, 2019*).

The customer journey map was taken back to the farmers in a second deep-dive interview. The purpose of this was to test the accuracy and validity of findings and analysis of the data collected from each farmer from the first deep-dive interview.

After a two-hour period, the HCD Facilitator guided each team to socialise their progress by describing the customer journey map of their farmer with the wider group. For the last hour of the first day, the interview teams using the feedback from the socialisation to improve their customer journey maps.

The interview teams spent the first hour of the morning on the second day reviewing their respective customer journey maps and making amendments. These were then taken back to each of the farmers for a second deep dive interview to synthesise the customer journey maps for accuracy. This second interview was also used to capture deeper insight from the farmers.

The deployment and reconvening of the interview teams was coordinated again to ensure that teams all came back together at roughly the same time.

When the interview teams reconvened at the central workshop venue, there was another round of socialisation of any additional findings and updates for each farmer. The download included, what had changed in the customer journey map, what was added, deleted and what was surprising. Following the socialisation process, the customer journey maps and the customer empathy maps were adjusted to empathetically reflect the validated farmers world.

The completion of this task concluded the first phase of work, problem discovery, in the early afternoon of the first day. This phase had identified many problems for each farmer. The next phase would go through a series of processes to refine these problems.

4.4 Phase 2 – Problem definition

The problem definition phase commenced early in the afternoon on the second day. This phase used processes to produce farmer personas, a value proposition canvas and a lean canvas for each farmer.

The information from the customer empathy maps and the customer journey maps, plus field notes were used to construct personas for each farmer. Personas were used in this project to create farmer centric archetypes based on the analysis of the data. Persona's were developed to encourage the interview teams to concentrate on farmers' unique characteristics. It enabled the development of the critical profile of the farmers in a summary form. They were constructed on large pieces of butcher's paper with sticky notes using the following headings; attributes, pains, gains, JTBD and an obvious opportunity for each farmer persona.

The personas were socialised with the group late in the afternoon of the second day. From this point on, each farmer was referred to by their persona title. Feedback from the socialisation was incorporated into the farmer personas.

The accumulative data from the customer empathy maps, customer journey maps and farmer personas was then used to construct a value proposition canvas for each farmer persona using sticky notes. The value proposition canvas was used to discover and refine farmers jobs-to-be-done. It is a canvas which has two distinct sides (see *figure 8*). The right side further refines the farmer profile by segmenting their pains, gains and jobs farmers were trying to get done. This is information fed from the customer empathy map. Then the right side of the map

is synthesised with the left side of the canvas is a value map which is populated by breaking a value proposition down into gain creators, pain relievers and products and services. It is important that the right side of the map is constructed before the left side. While this is counter intuitive from reading perspective, it is important to create the map in this order. A value "fit" is created when the value side of the map meets the customer side of the map in a manner which matches the pains, gains and jobs which are relevant and important to the farmer (A. Osterwalder et al., 2014).

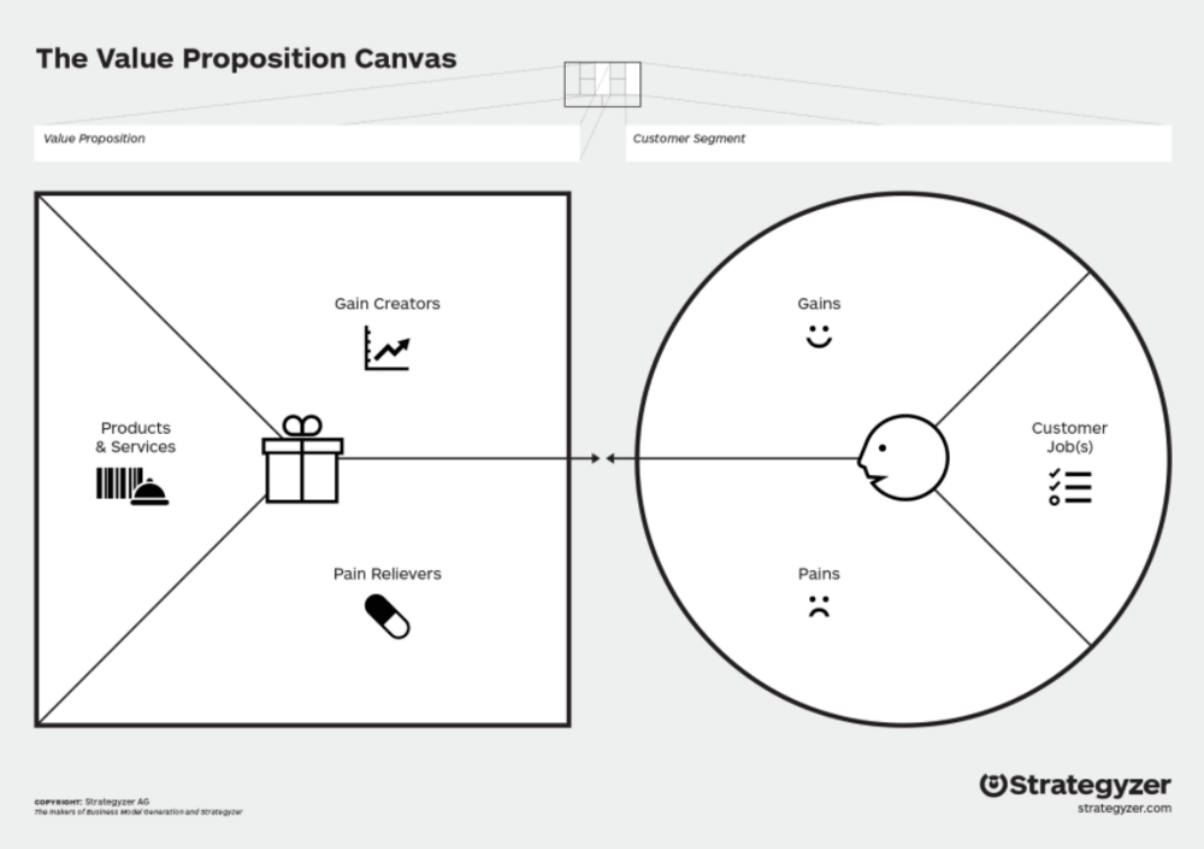

Figure 8: Value proposition Canvasp. (Source: *Osterwalder et al, 2014)*

The work on the value proposition canvas continued through to mid-morning on the third day of the workshop. At the mid-morning point, each interview team socialised their findings. The interview teams incorporated the feedback into the value proposition canvasses and then commenced constructing a lean canvas for each farmer persona.

The interview teams used the LEANSTACK lean canvas is a version of the popular Osterwalder & Pigneur (2010) Business Model Canvas (see *Figure 9*). The function of the lean canvas is to

map the market and customer need against a product or a service. The lean canvas is populated with data from the customer empathy maps, the customer journey maps, persona's, the value proposition canvas and interview field notes using sticky notes. It was selected as a tool due to its ability to support rapid construction and its visual, sharable format of a concise business concept (Lean Stack, 2013).

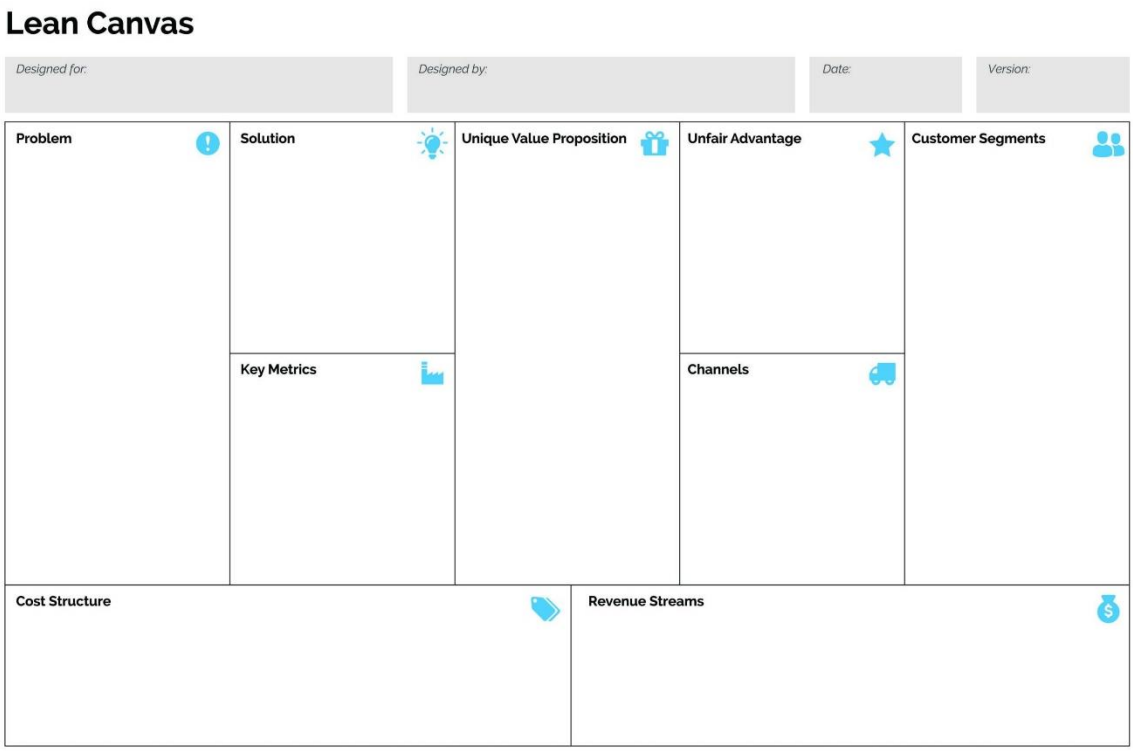

Figure 9: *The Lean Canvas.* (Source: *Lean Stack, 2013*).

This task ran until the end of the third day of the workshop. When the interview teams had completed these canvasses, they were all socialised with the wider group. This was the final task in the two three-day workshops.

Between the 17th of December and the 23rd of December, each farmer was phoned to thank them for their time and to update then on the initial key findings and the next steps in the project. Each farmer was encouraged to share their thoughts and experiences about the interview process and the interaction with the interview teams. This feedback was captured so that future interview processes could be improved.

This is also a transition point in this HCD process from phase two, problem definition to phase three, a solution concept phase.

4.5 Phase 3 – Solutions concept development

Phase three has two key components. The first component is the development of the solution concepts. The development of solution concepts was preparation work for the second component which was two synthesis workshops. The synthesis workshops were developed to test the solutions concepts with a bigger farming audience. These synthesis workshops had a sequence of three key stages which considered customer segments, common issues and solution concept development. The overall phase ran from the 21st of December 2015 to the 21st of March 2016.

The development of the solution concepts process ran from the 21st of December 2015 to the 2nd of February 2016. During this six-week period, the HCD facilitator and I worked together on this to prepare for two the synthesis workshops. The Palmerston North campus at Massey University was the location used in this phase in we called the war room. Through the analysis the key attributes of farmer personas and solution concepts. The synthesis workshops would be the testing ground to validate the outcomes of this work with a wider and bigger farmer audience.

The war room was a dedicated space where we could make all the data collected in the first two phases visible, in one place. One of its functions was a research wall. It had four walls painted in whiteboard paint which made it ideal for visually “mapping” thoughts, lines of inquiry, ideas, mashing together ideas and pulling them apart again. It was a place where the facilitator and I could be in the same room, the same place at the same time. It is a physical room, not a virtual or a digital room. Physical presence was important. It was important because insight and ideas were and bounced around. A lot of those insights and ideas were imperfect or “low on flesh”. We needed the benefit of brainstorming and understanding thought processes and the context of what the other was thinking and saying. There was a constant high degree of verbally challenging any blind acceptance of ideas and facts because all of the information was made verbal and visible. It meant understanding where ideas had come from, how it tied to the farmer interviews and farmer jobs to be done as a constant foundation. This could not be done remotely.

Brainstorming is a long-established creativity technique which is used by groups. It was popularised by Alex Osborn (1953). There are two very important elements of brainstorming of note in this context. The first is the practice of socialisation. The second is the practice of creativity. Creativity is a mental process. It involves combining and recombining material in a manner which creates new combinations of data, to create new patterns and combinations of ideas that can identify and create novel tangible and intangible items and objects of value (Auernhammer & Roth, 2021; Mumford, 2003; Sternberg, Sternberg, & Mio, 2011). An article by Auernhammer and Roth (2021) quotes Arnold's (1959) definition of creative performance; "creativity is made up of concepts such as questioning, observing, associating and predicting as creative attitudes rather than linear steps in a process." Further, Arnold (1959) talks about creativity attitudes which exist in the minds or personality of learners, seekers or creative problem solvers which can happen simultaneously, in any combination or sequence.

This phase was a highly iterative part of the process. The data were worked up by drawing concepts and ideas on a large whiteboard, sometimes with sticky notes and other times with whiteboard markers. The idea here was to rapidly work the data up over and over again.

Brainstorming was used when the facilitator and I were working in the same room at the same time. There was also a lot of time spent working with ideas, collating them visually on the walls with either sticky notes or whiteboard markers. This was also an important feature of the iterative process, the quiet contemplation of ideas and thoughts. Critically thinking about them and having the quite time to be able to do that. However, every step and stage went through vigorous socialisation which often spurred another round of verbal brainstorming. The quiet moments were not always in the war room. It was also valuable being able to step out of the war room and have the benefit of working through the massive cognitive effort of sensemaking which was quite often when breakthrough ideas occurred. We called them AHA! moments.

The war room made it possible and easier to work up the data and physically step back and look at it, think about it, debate about it and make changes over and over again. This creative process jumped around. There were a lot of ideas and combinations of the data which were identified. We considered expressed and latent farmer data.

There were two parameters which were always present in this ideation phase. The first was that the information was anchored to the farmers in the initial interviews so that no new data were introduced. The second was the anchoring to the farmers jobs-to-be-done. These two concepts were a plausibility test and a reference check which was mobilised through the iteration process. It ensured that through this phase, the farmer segment protypes and the common issues concepts were built in ways that were farmer relevant. The stop point is found when the ideation process delivered, in this case, personas and solution concepts that could not be improved any further based on the data we had.

There were two key outcomes from this phase. The first outcome was the design of granular personas, or farmer archetypes, which were a representative segmentation of our farming population. The reason we did this was to ensure that we were able to aggregate some of the common attributes we found across our initial farmer interviews and to separate out other key attributes. We also wanted to be able to consider and cater for a much wider sample of the representative farmer population and their respective pains, gains and jobs-to-be-done.

The second outcome was the design of common issues concepts. These were designed to prime and frame a conversation with farmers in the synthesising workshops about the intersection of their job-to-be-done in a particular aspect of their farming, and how technology could help them. Each solution concept had a key “job” as a heading. There were assertions to test each accompanying problem statement and a question to tease out more farmer insight and validation.

This iteration process produced 12 farmer segments and 11 common issues. These were printed onto A2 sized paper to be used as mini canvasses in the synthesising workshops. We nicknamed these synthesis workshops, validation workshops.

Two validation workshops were held, one in Palmerston North in the Manawatu and one in Darfield in mid Canterbury. The Palmerston North workshop was held on 2 February 2016 and the Darfield workshop was held on 21 March 2016. The workshops were held in the same areas where the first two initial workshops were held so that the original farmers from the first data capture could be more easily involved with the testing, validation and synthesis process.

The aim of the workshops was to test, validate and synthesise the customer segments and common issue concepts which had been developed based on the primary data from the first workshops and subsequent iterations.

All of the farmers who were involved in the initial interviews in the first workshops were invited to the validation workshops.

Twelve people, including seven farmers, attended the Palmerston North workshop. Of the farmers who attended, two of them were in the initial interviews. Four FarmIQ employees attended which included three staff involved in the initial interviews, plus the FarmIQ CEO.

Seventeen people attended the Darfield workshop. There were seven farmers including three farmers there who participated in the initial workshops. Five staff from FarmIQ attended which included three staff who participated in the initial interviews, plus the CEO and a senior manager from the Wellington Office. There were also two rural professionals, a senior rural sociologist from Massey University, the HCD facilitator and me.

We set up rooms in both locations, so we had the 12 farmer segment prototypes in one room, and the 11 common issues prototypes in another room. These were printed onto the A3 sized paper, and all were fixed onto the walls. There were an abundance of sticky notes and sharpie pens available for farmers to use, to capture their thoughts and improvements for each canvas.

Both workshops commenced with an informal gathering and finger food was available. This allowed for everyone to arrive and to socialise before the workshop commenced.

The participants were led through an overview of the process by a facilitator. This overview including a brief synopsis of FarmIQ's journey to date, the objective of the evening and how this process would add value to the overall design process and project. The facilitator explained that there were three stages.

Participants were given a sticky note pad and a sharpie pen each and encouraged to scrutinize the customer segment prototype concepts. The farmers were able move around to revisit

their inputs and remove them or rewrite them. This was a benefit of using sticky notes in this workshop.

Members from the original interview teams were available to rove around the room and to engage with and discuss the various concepts with farmers. These discussions with farmers uncovered more insights and information that was hard for some farmers to express. The interview team members could capture these thoughts in summary form and add to the canvasses.

The farmer/customer segment concept prototypes were analysed first. The facilitator explained these concepts to the farmer audience. The farmers analysed the customer segments first to prevent them from leaping into solution mode too fast during the preliminary stage of the workshop. Farmers added comments, changes, additions and suggestions for deletions by writing their comments onto sticky notes and attaching them next to applicable statements.

After a period of 40 minutes, the farmers were taken to another room where the *Common Issues* concept prototypes were displayed on walls. The farmers were allocated a further 40 minutes to offer feedback during this session. The same process was used as the customer segments process.

After synthesising processes with the customer segments and common issues, the facilitator led a process of uncovering which common issues were the most important to farmers that they would like to see further developed. The facilitator led a voting process for each of the common issues that was conducted in two stages.

In the first stage the three common issues with the highest votes were chosen each time to be discussed in more detail from a solution concept perspective. The project team had set up three tables with large pieces of plain paper on them so that each of the highest-ranking common issues concepts could be considered and the data and insights from the session could be captured. Once the first round of voting was completed, each table was assigned to a concept.

In the second stage, the farmers self-selected into groups according to which of the common issues and subsequent solution concepts were of the most interest or importance to them. The aim of this stage was to engage the farmers to capture information to understand about what attributes they wanted and would be willing to pay for in a solution concept. At each of the three tables, there was at least one FarmIQ employee present. This was to ensure that FarmIQ staff were asking curious and clarifying questions about different solution concepts. The other reason was to encourage the FarmIQ staff to engage with farmers directly to find technical insights about potential functionality they wanted.

The format for this part of the workshop was conversational to promote the cross section of ideas, contexts and sets of circumstances amongst farmers to address these common issues. The insights from farmers were captured by FarmIQ employees on the large sheets of paper.

This stage ran for around an hour. At the end of this hour, we collected up all of the data which included a careful pack up of all of the farmer segment and common issues canvasses and solution concepts with all of the sticky notes rolled up with each one of these.

We have discussed the synthesis set up and testing workshops. To summarise, the set up processes ran from the 21stth of December 2016 until the 2nd of February 2017. The two synthesis workshops were held in Palmerston North on the 2nd of February 2016 and in Darfield on the 21st of March 2016. The next process was to distil these findings into a final deliverable for FarmIQ. This work ran from the 23rd of March 2016 until the 13th of April 2016 and included another iterative process to develop the final deliverable to FarmIQ.

4.6 Phase 4 – Delivery of final solution concepts to FarmIQ

This phase of the work involved another ideation process back in the war room at Massey University over the period of two weeks, from March the 23rd until the 6th of April 2016. This was a very intense iterative process where the data were worked up again and again using brainstorming and data visualisation techniques. This was the same process which was used in the first war room ideation process with the facilitator and I.

The outcome for this process was the design and development of an initial set of final solution concepts for FarmIQ. This was the agreed deliverable. This process also revealed a minimum

viable product for FarmIQ. This work was produced through the continual process of brainstorming, debating and writing ideas and insights throughout this data work-up process. This also included writing stories about the day-to-day jobs of the customer segments, common issues and solution concepts which had been the focus of the synthesis workshops. The reason that stories was used as a technique here was so that we could arrange the information in different ways to open our minds to new ways to thinking about a solution fit for FarmIQ. This work helped us to focus on the attributes of an MVP for FarmIQ. The work produced the basis of a presentation of the initial findings for FarmIQ at a full staff meeting. To engage the staff, we used a storytelling method to introduce the analysis of the data. This method was a means of being able to describe our findings in a manner which would create collective buy-in by being able to explain our findings in a narrative form (Alexander Osterwalder et al., 2010). This method was supported with flipcharts which the facilitator used to draw simple diagrams as the story was being told to build the context whilst simultaneously describing our findings and deliverables.

During this time, I captured further fieldnotes of the questions, feedback and observations of the conversation which took place. These were used to by the facilitator and I to debrief and further refine the design of a second presentation.

The fieldnotes from the initial presentation were used in another intense iterative process which took place from the 7th of April until the 13th of April 2016. This iterative process was undertaken in the war room at Massey university by the facilitator and I. The feedback from the initial presentation were worked up and synthesised with the findings from our earlier iterative processes. This resulted in a refinement of the MVP and also the construction of a 2x2 matrix for FarmIQ.

The second presentation to FarmIQ was held on the 13th of April. This seven-day period was The second presentation was less formal and was held only with the senior management team of FarmIQ, the facilitator and I.

4.7 Conclusion

This chapter has outlined the methodology that underpins this thesis. The focus has fallen on the sequence of HCD activities undertaken with FarmIQ staff and participating farmers. Reconstructing and reflecting on this design methodology is my primary concern here. In pursuit of this objective, I collected a range of information which not only recorded the process but also fed back into it as a contribution to ongoing activities. Such action research is a complex undertaking and this complexity is intensified by the profoundly iterative character of HCD. Although the methodology has been presented in linear, narrative form as a succession of distinct phases, I have also emphasised a number of techniques that recur throughout the project. These recuring features cut across and so risk confusing the linearity of narrative, but they are an essential part of HCD and should not be overlooked. The thesis will now concentrate on the results and discussion chapter which considers the outcomes as a result of engaging with this methodology. Chapter 5 also discusses the challenges which can arise in an HCD process.

Chapter 5: Results and discussion

5.1 Introduction

The preceding chapter outlined HCD methods as an interactive process between participating individuals using a selection of design tools. This chapter presents the results of this process. Here I follow the same four phase, 'double diamond' narrative structure used to organise the methods discussion.

As I emphasise what we found out by using HCD methods, it should not be forgotten that these methods were tailored to the specifics of the FarmIQ project and its context. The flexible nature of HCD was identified as an advantage of this approach (Dorst, 2011). There are many other possible combinations of HCD tools, but there are also identifiable thematic points which are likely to stand as principles in successful HCD. There are some key learnings from this project regarding HCD roles and interactions, functions and principles. These will be considered as a series of reflections in the concluding chapter 6.

5.2 Phase 1 – Problem discovery

There were two key problem discovery jobs which had to be addressed. The first job concentrated on finding the right job for FarmIQ to solve. The outcome from this served as the project design frame for the overall HCD project. The second job, to find the right problems to solve for farmers, commenced when the project plan was formally signed off by FarmIQ. The process and importance of discovering the clear problem to solve as the first job was supported in the literature (Beckman & Barry, 2007; T Brown & Kātz, 2009; Kimbell, 2011).

The first problem discovery job was undertaken by the project facilitator and myself. We knew that FarmIQ recognised they had to do something to reboot sales and to stem the flow of farmers who were cancelling their subscriptions. The CEO knew that the problem and the solution were more complex than being a straightforward matter of marketing, but he could not put his finger on it. To better define the problem we needed to solve for FarmIQ, we went through a process of unbundling their current context. This process gave us the opportunity

to understand the nuance of the organisation and to help us start designing a HCD project brief.

Our two-person project team undertook a series scoping exercises with three farmers. These were interviews with extreme users and non-users of the FarmIQ System. I attended a FarmIQ introductory workshop and went to a presentation about a competitor's farm software products. Internet and media scans were done to establish and examine other offerings in the New Zealand market. Lastly, interviews with senior managers at FarmIQ were undertaken to establish and analyse FarmIQ Systems' development processes. All of these interactions created data for analysis.

Analysis suggested that the research and development processes used by FarmIQ had failed to usefully identify the basic JTBD that farmers wanted solved.

FarmIQ had used a focus group and pilot approach, which targeted and engaged with very progressive farmers, had been used. This process had generated a series of insights which included 1,200 user stories. The information gathered, including all of these user stories, were transformed into a complex bundle of software solutions. These stories elaborated a wish list of attributes and functionality that farmers would *like* to have. However, none of the attributes or functionality were aligned or associated with any specific farmer segment and their specific JTBD. Even though the back-office product FarmIQ had built was world class, it was impossible to validate any of the FarmIQ attributes and functionality against specific problems that farmers wanted solved. Instead, a simplified version of the technology adoption bell curve segmentation approach was used. This was discussed in chapter three.

The resulting software package that was developed and commercialised was too complicated for all but the most sophisticated farmers. Farmers who cancelled their products told us the software was too complex to use and found the system very data hungry. This made the system very difficult to step away from as its functions were too hard to explain and train someone else to use. The amount of value created from the system did not match the level of sophistication that the system presented. These farmers also told us that the data inputting effort required and the information outputted did not justify the expense of the subscription, or their levels of frustration. We found that the farmers who continued to use the system had

a high level of comfort using agtech and a very high pain tolerance for adopting new technology.

We also discovered that the way the software was bundled meant that most farmers had to buy the most expensive pack to use the one or two basic tools which they really wanted. The overload of features in this pack overwhelmed many farmers. The ability for FarmIQ to easily tailor a package to the basic needs of individual farmers did not exist. The "pack" approach was taken to be more cost and time efficient than tailoring to individual farmer needs.

Attendance at the evening introductory workshop revealed that the system did not easily fit within a farmer's day-to-day life. There was only one potential new client who attended this evening. The main system [at this stage] seemed to be computer oriented, which was not in keeping with the increasing uptake of smartphones amongst the farming population[14]. Any work underway to provide a mobile phone solution was early in development. The interface of the system was hard to navigate. Many of the functions were hidden, making it complicated to use because of the number of screens that had to be opened. It was not intuitive for non-savvy computer users, so they gave up during the session.

We sensed that farmers, of all ages, had decreasing tolerance for software that was clunky to use. We were finding that farmers were fast becoming accustomed to using their touch screen mobile devices. They liked the user-friendly and intuitive nature of smartphones and their wide selection of easy-to-use apps.

We observed that familiar "farm" language was important to farmers. We learned that some of the terminology used by the software system and the FarmIQ staff differed from the day-to-day language used by farmers. This made it difficult for farmers to identify what their issue was and hard for FarmIQ to decode and remedy those issues.

The FarmIQ business plan drove a quite linear design and development process that produced a paradoxical outcome. On the one hand, through the process FarmIQ were able to build a software system with all the functions and attributes that farmers wished for. On the other

[14] Smartphone adoption was just beginning to accelerate, which in part was due to increasing mobile phone coverage in rural areas. At this time, FarmIQ were starting to build their mobile phone functionality.

hand, the volume of functionality and attributes built into the system was overwhelming for farmers, except for those with a high cognitive ability to adopt and use complex technology. The business plan contained a tight and ambitious schedule of sales and financial targets and milestones which were becoming increasingly distanced from where the FarmIQ reality was.

It seemed hard to make changes to the system[15]. Our hypothesis was that this was because the back-office suite had been coded and developed by an external organisation. We wondered if changes to the software had to be translated several times, because the software development organisation was not in direct contact with farmers. We considered if this increased the risk of key messages from farmers to software developers being lost in translation. Therefore, we wondered if it was hard to create effective fixes.

The result from our process of discovery and analysis was the design of the project brief.

Once FarmIQ had signed off the project brief, we were ready to commence with the HCD process proper. The second problem discovery, understanding the farmers problems, was accomplished by a first round of farm interviews by the full project team. These interviews were done as part of 2 regional workshops, with the initial results being worked up into two important artefacts, customer empathy maps and customer journey maps. However, before the first interviews were undertaken, the facilitator took the interview teams through a training exercise.

The first day of the first workshop, which was in the Manawatu, began with the wallet exercise which ran for three hours with the four interview teams. The wallet exercise gave participants an understanding of how important it is to wholly listen to and observe farmers and to work carefully through the problem finding process before considering solutions. This exercise helped promote and develop the skills of empathy. This was important to help build capability in identifying both the expressed and latent problems or opportunities of end-users. It increased the interviewers' capability to seek clarity and understanding through crafting questions to increase, check and confirm understanding. The interview teams became more comfortable with awkward silence by not filling people's thinking time with more

[15] FarmIQ had identified the best technology at the time of their development work, however, the advancements in technology had advanced between this period and the HCD project.

questions. Additionally, interviewers learned to be alert to non-verbal cues from the other person and thus to appreciate the benefits that observational techniques could yield in terms of information and insights. It was important to have the facilitator there to guide the process, maintaining the momentum and communicating key objectives.

Once the wallet exercise was completed, the four interview teams were ready to interview farmers. These were done as part of the two three-day workshops held in the Manawatu and in Mid-Canterbury. These workshops were organised by a repeated framework.

On the first day of the workshop, four interview teams were formed. Each was a pair made up of a FarmIQ employee and a Massey University sourced interviewer. We convened at the workshop venue, where each pair was allocated a farmer. At the same time, the interview teams had a physical space allocated to them, which would be their research wall to be used for all of their data collation and analysis. A brief introduction about each farmer was socialised with the entire group. This helped each interview team to familiarise themselves with what type of farm system and farm family they were going to. This meant that the teams had the benefit of a warm rather than cold start to the initial interview, so that both they and the farmers could settle into the task much more quickly and effectively. Before the teams were sent out to the farmers, the facilitator gave final advice on conducting the deep dive interviews with empathy, and an approximate time to be back at the workshop venue.

There were many micro results from having two-person interview teams. It was easier for one person to concentrate on asking curious open-ended questions and for the other interviewer to take notes. Between two interviewers, the verbal and nonverbal communication and observations could be captured and noted. The length of travel between the workshop venue and the farmer's preferred meeting place meant that interviewers had the opportunity to debrief and compare observations. This socialisation opportunity helped the interview teams to start analysing and unpacking their captured raw verbal and non-verbal interview data. The two-person concept also minimised the risk of single interviewer bias and the temptation to introduce information based on researcher stimulus into the data.

The interview teams reconvened at the workshop venue within an hour of one another. Once all of the interview teams were back, the facilitator supported the whole team through the

first of the socialisation sessions. In this session, the four interview teams gave the entire group their first overall impressions and analysis of each farmer. This gave all the teams an opportunity to ask and to be asked questions about their farmer, prompting them to dig further and build deeper understanding, to improve clarity in key messaging and identify any initial blind spots in their farmer data. It was important having the facilitator there to emphasise empathy by guiding the questions back to relevance for their farmer.

Using sticky notes, the raw data from the first farmer deep dive interview was used to construct two artefacts: a customer empathy map and a customer journey map. Each map was attached to the wall. The raw data was collated by the interview teams through their capture of fieldnotes and recall of verbal and non-verbal communication during their interviews. This meant that the interview teams could add any latent information that they had noticed during their interviews. Examples of this included the observable context and tools which farmers were using, such as did they seem to use books and binders, phones, computers and so on. They were also able to incorporate non-verbal communication, such as seeing when farmers seemed excited, frustrated or self-conscious. The risk of adding interviewer bias through the addition of latent information was mitigated through the subsequent validation exercise, which was done in the second set of farmer interviews. Any information which was not true or misleading would be removed at this stage.

The customer empathy map was constructed first. This assisted the building of a deeper understanding of each farmer by working through questions divided into six segments (*See Figure 10*). The visual nature of the map (and all subsequent maps and canvasses) helped to not only see what information we had discovered, but also to identify where we had information blind spots about each farmer. This was advantageous for setting up for the second deep dive interviews.

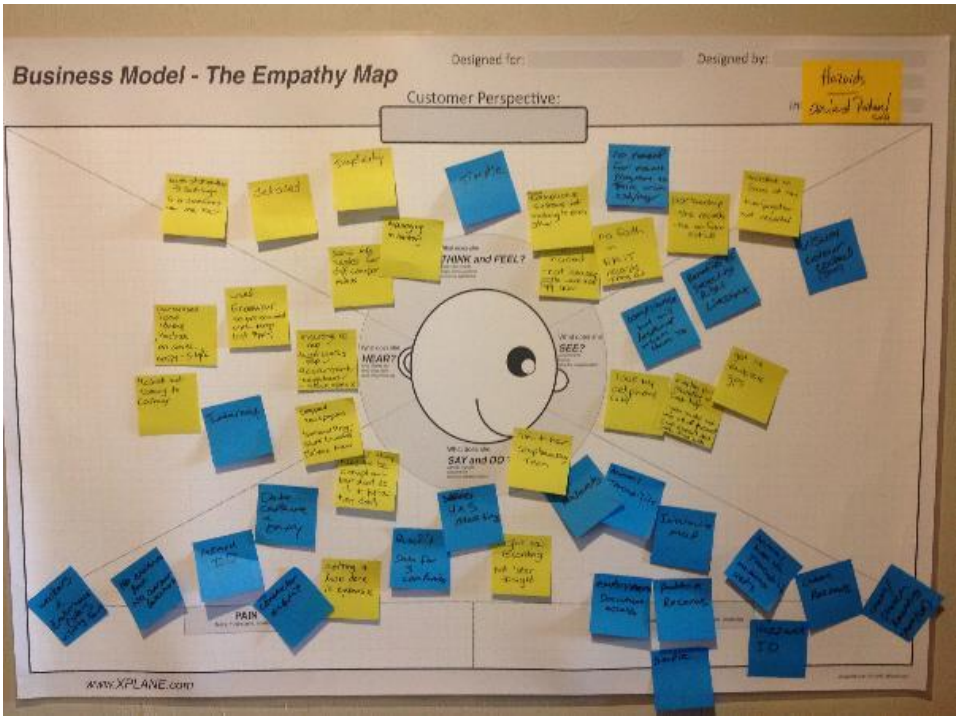

Figure 10: Example of customer empathy map.

After two hours working as separate teams, there was a facilitator-led socialisation process to discuss each of the customer empathy maps. The teams shared their progress and findings regardless of how much information was filled in. The sharing of imperfect and incomplete information, and the idea of constant return, would become a normal practice during this workshop. The empathy maps resulted in a first ordering of the farmer data and gave each interview team an early insight into what their farmer's main pains and gains were.

The raw interview data, in conjunction with the customer empathy map, was then used to create a customer journey map. An example of the template we used is shown in *Figure 11.* The customer journey map guided each team in unpacking their farmer data, using a chronological and narrative approach to understand the different elements within this matrix. This helped to focus attention on various points of interest as well as discover any further blind spots. One of the means we used to understand our data blind spots was through the blank areas in each canvas.

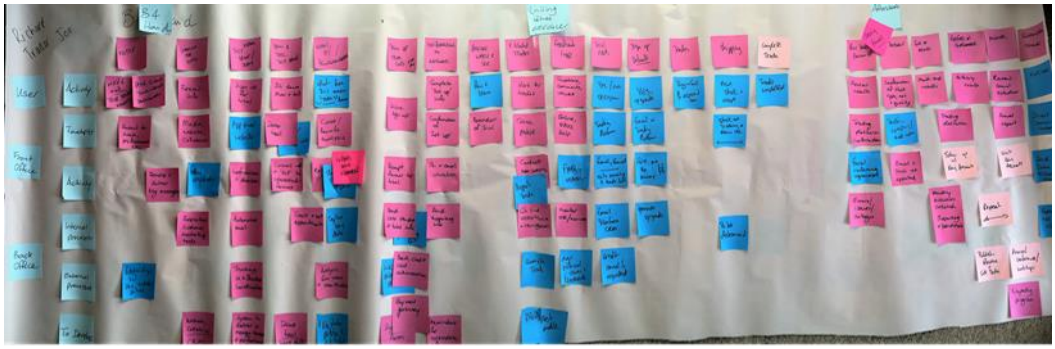

Figure 11: Example of customer journey map

Though the customer empathy map was created first, there was a lot of toggling between these two maps. This iterative process improved both maps. The customer journey map of each farmer was the artefact which would be taken back the same farmers for their second deep dive interview. Each farmer would evaluate the accuracy of their "customer journey" and to share further insights. At the end of the first day, the facilitator called for a round of socialisation of both the maps that had been produced.

Day two of the workshops each interview team revisited the customer empathy and customer journey maps previous day's work by opening with a round of facilitator-led socialisation. This revisit gave us all an important insight into the benefit of overnight reflection, resulting in further improvements to the customer journey maps in preparation for them to be synthesised with each of the farmers. The second round of deep dive interviews were then conducted at a time and place agreed with each farmer. Farmers provided validation checks on the work already done. Farmers were very comfortable to offer feedback about their story and to challenge concepts, especially if the analyses did not fit. The farmers were very honest and confident, and it was easy for them to make changes or agree with what they were presented, something that built valuable trust into the process. Using the tangible customer journey maps and sticky notes made this interactive process easy. The farmers got materially involved with moving sticky notes [data] around and removing information which was not true or relevant. They were also able to add information to their maps. Moreover, the interviewers were able to test hunches and perceived latent insights. The risk of this being captured by interviewer bias was mitigated because the farmers were very comfortable correcting information about themselves if it was untrue or inaccurate. An alternative truth

was frequently offered in this case, and in this case, it seemed easy for farmers to communicate these alternative insights.

It seemed that this reciprocation process of information exchange increased the level of comfort and trust between the farmers and the interview teams. This is another positive nod to the importance of socialisation in HCD processes. The farmers gave the interview teams the benefit of sharing their thoughts and the interview teams reciprocated by providing evidence through the customer journey maps of their depth of listening and genuine attempt to understand the farmers' world. For example, this process allowed one farming couple to completely alter the journey map they were presented with. They did not feel that the data analysis and interpretation of their interview was a reflective fit of them or their issues. I followed this up with a phone interview with this couple a week after the workshop. Though they were surprised that the information was not accurate, they were very pleased that they had the opportunity to correct the work with the interview team. The farming couple liked the process because it was open and transparent. They appreciated the effort to ensure the information was a true representation.

The interview teams reported that they experienced a higher level of rapport with their farmers in the second interviews. They found that they had all settled into their second interviews very quickly. This allowed for deeper questioning of and insights from the farmers. Farmers also provided extra relevant information which was not "on the top of their heads" during the first deep dive interview.

As with the first deep dive interview, the teams had the benefit of being able to debrief amongst themselves while travelling back to the workshop venue and identify areas of material interest to their data capture and interpretations. These conversations during field trips resulted in much faster analysis work once back at the workshop venue because of the increasing rapport between team members, which enabled them to more confidently and safely discuss and debate findings and observations.

Once interview teams returned to the workshop venue from the interviews, each fixed their customer journey maps back on the walls. The facilitator then assisted them through an around-the-room socialisation process. Each team talked about the discoveries of additional

data, what had changed on their customer journey maps and what had been moved or deleted. The sticky notes were an important part of this process as they allowed the mapped data to be easily moved, added or removed. In this way the new data from the second interviews was used to improve the customer empathy and customer journey maps.

As the above account of the workshops suggests, the experience and skill of the facilitator were crucial to the teams being able to undertake work that for most of them involved learning new practices unlike those they had relied on previously. The presence of the facilitator ensured there was an objective ear listening out for and resolving any interviewer bias. He also ensured that the focus was reflective of the farmers interviewed, persistently asking good questions that teased out deeper information and meaning from the data. The completion of eight customer empathy and journey maps concluded the first, problem discovery phase of the HCD process mid-morning on the second day. The focus then shifted immediately to the second phase, problem definition.

5.3 Phase 2 – Problem definition

Three key artefacts were produced through in the second phase of the project: farmer personas, value proposition maps and lean canvasses. As noted above, these artefacts were made within the frame of the project's workshops. *Figure 12* shows the format used for farmer persona development.

Figure 12: Example of farmer persona development

Using their previous mapping work, each of the interview teams produced a persona for their farmer. The following template guide was used to construct the eight personas:

- *A persona name*
- *High level description of my current situation*
- *[My] biggest pains*
- *[My] biggest gains*
- *[My] key job-to-be-done*

The following eight farmer persona's were developed:

- Family operation dairy farm
- Multi-system farmer
- Bull farmer
- Shepherd with a farm
- Sheep and beef and arable farmer
- Transitioning into a sheep and beef farm
- Arable mixed cropping and lamb trader
- Ops manager for multi dairy farms.

These farmer personas developed the key attributes for each of the farmers and identified that many other farmers would be trying to get similar jobs done. Constructing the eight farmer personas helped to further tease out the key attributes for each farmers by summarising their unique attributes. The process of developing the personas revealed that each farmer had many jobs and an overarching job that they were trying to get done. This work helped the teams to transition from thinking about their farmer as an absolute individual to thinking about them more broadly as a potential customer segment. Each persona suggested the possibility of similar jobs that other farmers might also be trying to get done. *Table 3* shows the summary of the eight farmer personas.

	Family operation dairy farmer	Multi system farmer	Bull farmer	Shepherd with a farm farmer	Sheep, beef & arable farmer	Transitioning into to sheep and beef	Arable mixed cropping & lamb trade farmer	Ops manager for multi dairy farms
Main JTBD	Create time, make communication easy	Oversight and control	Life's easy, no worries	Make my life easy	Assurance on compliance	Easy entry	Easy exit	Over sight on assurance and over staff
Farm structure	Multiple farms	Multiple farms	1 farm	1 farm	1 farm	1 farm	1 farm	Multiple farms
Number of farming systems	1 system	Multiple systems	1 system	2 systems	2 systems	1 system	Multiple systems	1 system
Complexity of operation	Low/medium	High	Low	Low	Medium	Low	High	medium
Level of financial stress	High	Low	Low	High	Medium	High	Low	medium
Phase of farmer life cycle	Early in career	Mature	Mid life	Early in career	Mid life	Transitioning into farming	Close to transitioning out	Mid life
Technology adoption pain	Low	Medium	Medium	High	Low	Low	Medium	Medium
Level of tacit knowledge	Low/medium	High	High	Medium	High	Low	High	high
Personnel change impact	Medium	High	Low	Low	Medium	Low	Low	medium
Staff	Yes	Yes	No	Yes	Yes	No	No	yes

Table 3: Summary of the eight farmer personas.

The eight farmer personas were socialised once more across the full group, resulting in further refinements. At this point, a value proposition canvas was developed for each farmer using all the data and artefacts previously collected (*see Figure 13*).

Figure 13: Example of a value proposition map.

These canvasses are populated in a particular order. The right side of the canvas, profiling the farmer's pains, gains and jobs, was constructed first. Then this was used to complete the left side, which breaks down the farmer value proposition into pain relievers, gain creators, and on this basis detailed the specific products and services that FarmIQ could offer to farmers. This analysis required considerable iteration to find the key insights and the obvious JTBD for each farmer. The ease of populating this canvas depended heavily on how clearly and accurately the pains and gains were identified in the customer empathy and journey maps. Consequently, there was a lot of toggling between these maps and the value proposition canvas.

It was relatively easy to identify what the pains and gains were for each of the farmers because this information was by now becoming quite familiar. It was much harder to analyse what the JTBD were, and to find the initial jobs for some farmers. Farmers who had obvious pains seemed to be easier to analyse than those whose pains were more difficult to pin down. The latter required more work to tease out what was needed. The facilitator helped the process by asking different questions to encourage the teams to look at their information in a new way.

The level of creativity amongst the teams was clearly influential. Creative mindsets enabled some to think outside of generic ideas and ideals, while others found it easier to divulge what was safe and non-disruptive. The value proposition canvas helped to encourage a shift in thinking from inside FarmIQ looking out, to outside FarmIQ looking in. The canvas focussed attention on the farmer world, away from any retro-fitted, organisationally biased information. Moreover, its concentration on the farmer JTBD helped to abate the temptation to leap too soon to the creation of solutions.

The resulting eight canvasses concisely presented a value proposition for each farmer persona in a clear and visually organised manner. The journey maps continued to be revisited and improved throughout this process, with iterations often resulting in the generation of new insights from the second round of interviews. Ongoing analysis continued to reveal farmers' latent needs and helped to identify where the opportunity spaces and gaps were in the current FarmIQ offerings. The canvases provided the teams with placeholders to park this information and helped the team members to critically reflect on FarmIQ processes. Day two of the workshops ended with a facilitated socialisation of each team's progress with their value proposition canvases.

During the first hour of day three, the interview teams reflected on their work so far, tweaking and improving their value proposition canvasses. These refinements were socialised and then each team was allocated a Lean Canvas (*see Figure 14*).

Figure 14: Example of a lean canvas.

This was a real turning point for the FarmIQ staff, as the focus now turned to the first of the attempts to work towards mapping potential solutions for each farmer persona. Energy levels visibly increased amongst the FarmIQ staff. This was their first opportunity to map the most important task of each farmer relative to the business model of FarmIQ. This seemed like more familiar ground, as it was working towards the development of solution concepts. The lean canvas did, however, take the teams through this exercise in an ordered process that involved working through the following 9 steps:

1. Problem statement
2. Customer segment
3. Unique value proposition
4. Solution
5. Unfair advantage
6. Revenue streams
7. Cost structure
8. Key metrics
9. Channels.

This process meant that the solution and its business model were progressively unbundled, ensuring that every key aspect of the solution was explored and researched. Although arranged sequentially, the task was highly iterative, with much working back and forth across the canvas. This proved a valuable exercise for FarmIQ staff, as the teams got to work discovering the challenges and risks of various solution concepts and the task of justifying their different customer segments and value propositions. The artefacts and fieldnotes from previous work were an important ground truthing reference for this task. At a midpoint of this process, there was a socialisation of each lean canvas facilitated with the wider group.

A second socialisation session was held at the end of the third day, which also marked the completion of the first workshop. All of the work that was created for each farmer persona was collated and rolled up into eight respective bundles. This concluded the project's second phase and set the stage for further work focussed on the development of solutions concepts.

5.4 Phase 3 – Solutions concept development

Phase three produced two key results for the project. The first was the development of very granular farmer personas, which we called customer segments, and a series of common issues prototypes. The second result came from the testing and further development of the prototyped personas and common issues at a two synthesis workshops with a bigger and broader farmer audience. The synthesis workshops were nicknamed validation workshops. This work formed the basis of the project's concluding phase, the design of the final deliverables for FarmIQ.

The methods chapter outlined the solutions development process in quite granular detail. The work was undertaken over a six-week period by the facilitator and myself. During this time, the data collected from the first workshop were worked up using the HCD techniques described in chapter four, through a number of small rapid development repetitions. We dug deeper into the initial workshop findings to develop latent features, characteristics and attributes for each of the eight farmers and to establish some common themes. This was an intensely iterative process, with the data repeatedly bundled, unbundled and re-bundled.

Multiple ideas for farmer persona development and solution concepts were continually being identified and developed. Some ideas stuck and others were dropped as the iterative process identified what was valuable. The data were reconfigured again as user stories, with each story accompanied by a journey map that could be evidenced with links back to the data.

Numerous visual artefacts were created on the war room walls, with some iterations lasting only a minute before being rubbed away and reconstructed in another way. Each time the process came to a standstill, the key insights were gathered and used to commence the front end of the next process of persona and issue identification (see *Figure 15*). We knew that we were finished when we had achieved our goal of distilling all of the key JTBD from the first workshop as a series of grounded truths that combined both obvious and latent insights. We used these JTBD encapsulations for further persona development. The resulted in the creating a series of low-resolution prototypes of persona and common issues concepts. We knew that these were not perfect, but we also knew that they were robust enough to encourage participation and experimentation with farmers. Indeed, this was the very purpose of these artefacts – they were designed to be taken into the second workshop series for a validation

process that would identify any bias or ideas that the farmers disagreed with or felt needed to be modified somehow.

Figure 15: Images showing small example of data work up to create customer segments.

As outlined in the previous chapter, two farmer validation workshops were held. Twenty-nine people attended the meetings in Palmerston North and Darfield. This number included five of the original eight farmers who were interviewed in the first workshop phase.

The same format was used in both locations, with each validation workshop made up of three distinct parts. The first two parts gathered feedback and insight from farmers the on the conceptual customer segments and common issues respectively. These were printed onto A2 sized paper and were stuck on walls and the farmers participated by writing key points and thoughts on sticky notes and sticking them next to relevant sections (see *Figure 16a* & *Figure 16b*). They were also assisted by FarmIQ staff, the facilitator, a Massey University rural sociologist and myself. The use of sticky notes prompted discussions and questioning, removing invalid data and generating new key insights that improved the concept prototypes. I also made observations and kept field notes for subsequent reflection.

Figure 16a

Figure 16b

Figure 16a and 16b: Illustrating farmers sticking comments onto customer segment and common issues canvases in validation workshops.

The third part of the workshop had two key processes. The first process worked to identify the common issues which farmers ranked the most pressing or important to them (see *Figure 17*). This was achieved through the facilitator running a voting process.

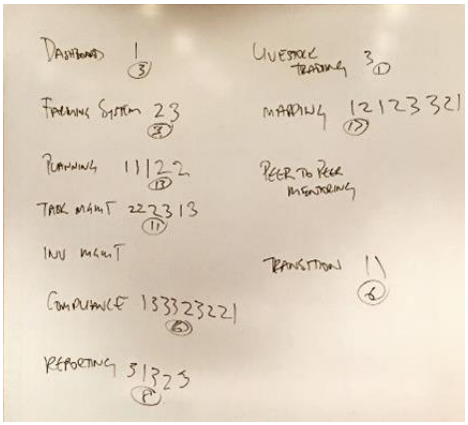

Figure 17: Illustrating the voting process used for farmers to identify solution concepts.

This insight was very useful for the next phase of work. Secondly, we gained a high-level understanding of what problem-solving functionality farmers would be looking for and were willing to pay for, functionality that they felt could address the common issues they selected to concentrate on.

This led to the second part of the third phase, which was the farmers working with FarmIQ staff to tease out the solution concepts. This was achieved with farmers selecting a table with their preferred solution concept on it. Farmers worked with a FarmIQ member to brainstorm ideas to build their ideal concept (see *Figure 18*).

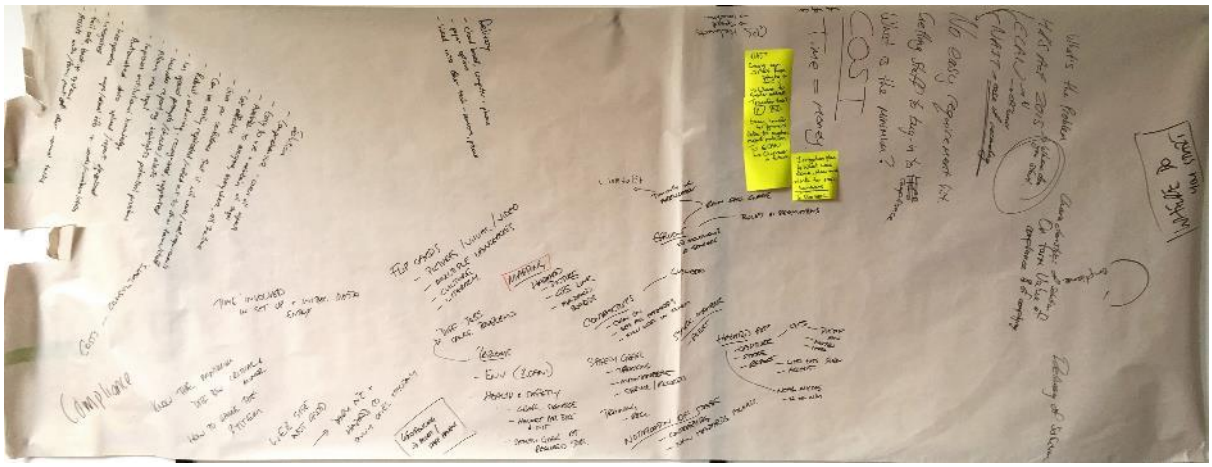

Figure 18: Example of a solution concept mapping exercise.

5.5 Phase 4 – Delivery of final solution concept to FarmIQ

The insights gathered from the two validation workshops were used to work on and construct the final deliverables for FarmIQ. This was a two-week process undertaken by the HCD facilitator and I in the war room at Massey University. This involved an intensive work up of the data and insights collected from the two validation workshops. As with earlier war room sessions, some of the ideas and data work up stuck and other ideas dropped off as the material for the first presentation was being identified as a set of preliminary findings. The reference back to the material gathered in the validation workshops was continual to ensure the preliminary findings were grounded in the farmers world. Multiple stories were constructed and adjusted and at times deleted in this process. The large whiteboard spaces were valuable for this process by being able to make the data and the data work ups visible. Once we got to the point where we found that no further improvements could be made, we

were ready to present the results to FarmIQ. The results were presented to FarmIQ in two stages; a preliminary findings session and a final deliverables session. The first presentation was based on a story narrative (see *Figure 19*).

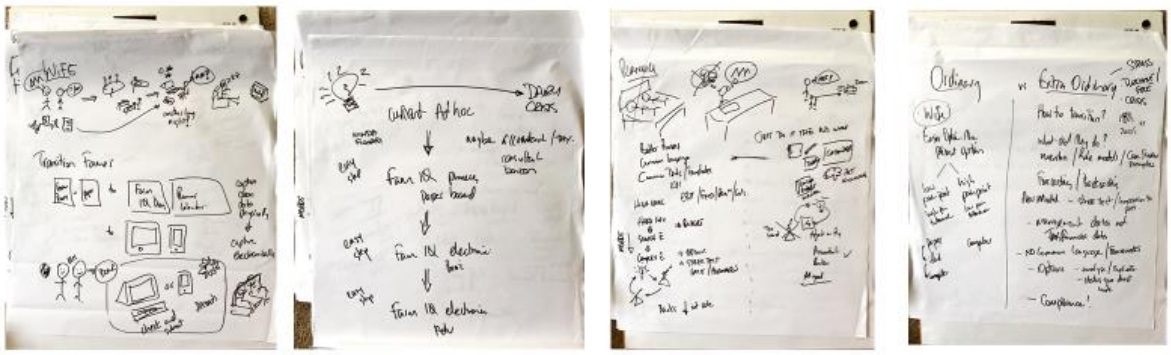

Figure19: Showing the story narrative structure for the preliminary findings to FarmIQ.

This session generated a lot of questions and feedback from FarmIQ. There was a general consensus about the nature of the results, however, the project team needed to do more work to ensure that the results were able to be incorporated into FarmIQ and operationalised. The feedback which was collected from this workshop were used to inform the final deliverables and overall result.

The overall result from this work was a general solution concept for FarmIQ, the project's agreed deliverable. Along the way we also discovered a minimum viable product (MVP) concept.

An MVP is described as "that unique product that maximizes return on risk for both the vendor and the customer" (SyncDev, 2017). The term MVP was first coined in 2001 and was quickly established as a segue between business and technology offerings (Ries, 2011). MVP's support commercial success because they ensure that offerings to the customer are not an overly bloated suite of sophisticated attributes (SyncDev, 2017). Unnecessary attributes and excessive sophistication can cut returns, while inflating risk for both those who purchase and develop them (SyncDev, 2017).The identification and release of an MVP lowers organisational risk for businesses, developers and the end-user while maximising return on investment (Cleland-Huang, 2015; SyncDev, 2017).

Though design thinking and MVP writings have been in circulation for two decades, the literature is sparse in terms of how one complements the other. When working through development projects, much thought has to be allocated to both the features of the product and their priority level, which has large implications for the products produced in terms of accomplishment and marketability (Cleland-Huang, 2015). Often the outputs from such development projects are overdesigned products which are too sophisticated for those who are intended to use them, resulting in an offering which carries significant risk to the organisation (Duerden et al., 2016) . The flow on effect from this lies in the lacklustre results when evidence of poor marketability and organisation accomplishment emerge (Cleland-Huang, 2015). This is often because the creation of such offerings has been overly influenced by the preconceptions of project stakeholders (Cleland-Huang, 2015). In such situations, a focus on MVPs can help to transform the design process.

While the definition of a MVP offers an insight as to what the development and output consist should of, it must also be acknowledged such insights are often challenged by the mindset within organisations (SyncDev, 2017). Mindsets which continuously add idea after idea may maximise the contributions of organisation members, but they also typically create overdesigned offerings which soak up large amounts of investment and pose the risks associated with feature creep (SyncDev, 2017).

The process of developing MVP's fits with the methodology of design thinking as it supports the process and solution development. The process is supported through the requirement of synthesising and empathising with end-users, their JTBD and their most painful and frustrating problems (Duerden et al., 2016; SyncDev, 2017). These are opportunities, and they can often be hidden.

The MVP concept for FarmIQ was a visual interface. The desirability of such visualisation was overwhelmingly supported by consistent, validated analysis across all of the farming segments. The interface offered a mobile solution that can support many different modules, allowing the farmer to add other features when desired. Such functionality makes using devices easy and intuitive, enabling them to be readily accessible in a farmer's day-to-day problem solving. The MVP solution has very wide appeal to a large majority of the farming population, but its flexibility also means that it is not limited to farmers who want a minimum

offering. In keeping with the definition of a MVP, the offering is able to be scaled as and when needed by the farmer.

The farm map was clearly the most desired interface for farmers. This is due to the number of farming operations that are assisted with mapping, such as communication, hazard identification, tasking, stock shifts, pasture management, record keeping and tactical planning. For example, a farmer can identify farm hazards on a map in one or two very easy steps. A solution such as this helps the farmer to step into the FarmIQ system at a very accessible level.

The second solutions concept delivered to FarmIQ was a farmer profiling and problem mapping tool. This was the result of the intense iterative process over a seven-day period in the war room at Massey University in Palmerston North. The first iteration resulted in a mapping diagram to unbundle ordinary and extraordinary opportunity spaces (see *Figure 20*).

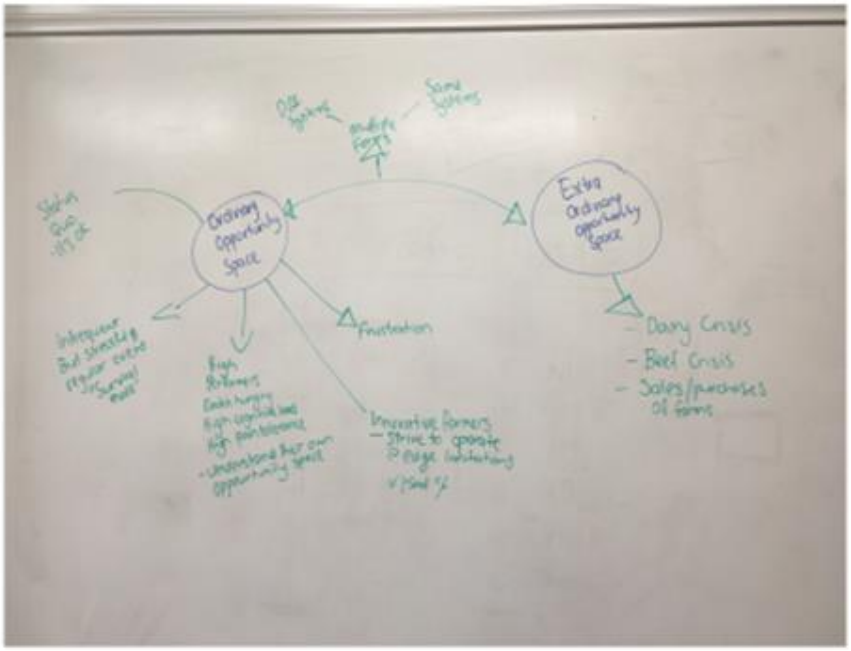

Figure 20: The first diagram of ordinary and extraordinary spaces.

This led to a second iterative process involving brainstorming and debate which resulted an early concept of a 2x2 matrix. This used personas to concisely communicate the opportunity spaces and redefine the relative customer segment (see *Figure 21*).

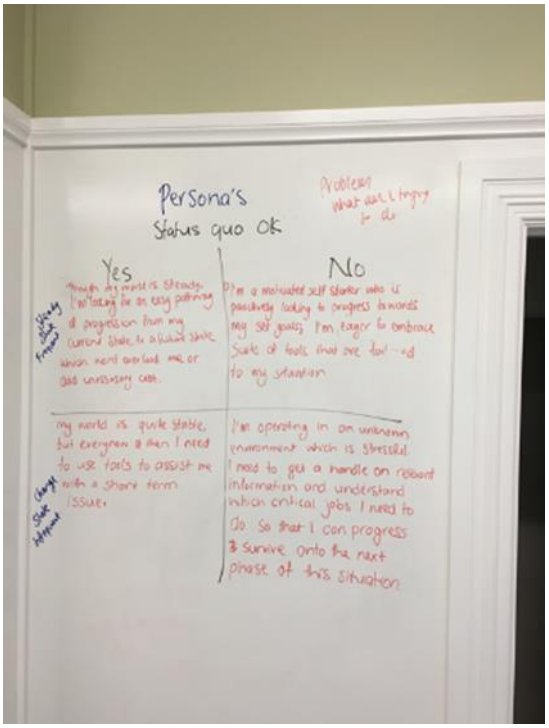

Figure 21: Second iteration outcome resulting in first 2x2 matrix based on farmer personas

The first iteration was relayed through a metaphor. This was based on a farmer going through a farm merchandise store to further test this concept based on a stable or unstable environment and farmer JTBD. Initially we ended up with these three versions:

1. A farmer who is in a hurry runs into his local merchandise store to quickly pick up a product to fix a farm crisis which happened this morning. There is no need for a trolley, or the input or help from the salesperson because they know what they want and where to find this one product. The product is purchased without any delay or pause for discussion. The farmer then takes it home and installs the product. The crisis is averted and the day can resume as normal.
2. A farmer enters into their farm merchandise store with a list of products that are needed for making a change to an important system on the farm. Because some of the changes require different products than normal, the farmer needs to discuss what the options and various costs are to implement the best solution for this change. Through a discussion to find out what the overall outcome should be the farmer and the salesperson put together a range of products to get the job done.
3. There has been an event in the farming environment which means that the farmers particular system has to change or else the future of the business will be in jeopardy.

The event requires more than just the sales rep at the local rural merchandise store, it requires a triage approach. To receive the help the farmer needs to engage the specialised advice from the vet and will also require input from the fertilizer rep perhaps a farm consultant to put together a set of options to triage the situation. The farmer knows that there must be significant change which will be long term.

Although there were only three initial scenarios, through a process of further reflection, brainstorming and debate, the design team rapidly constructed the next 2x2 matrix which was repeated times (see *Figures 22a, 22b, 22c*). Each version of these 2x2's was used and considered to make the next version better. This involved debating and agreeing with what the most appropriate labels on the two axis were and the most appropriate JTBD concept for each quadrant.

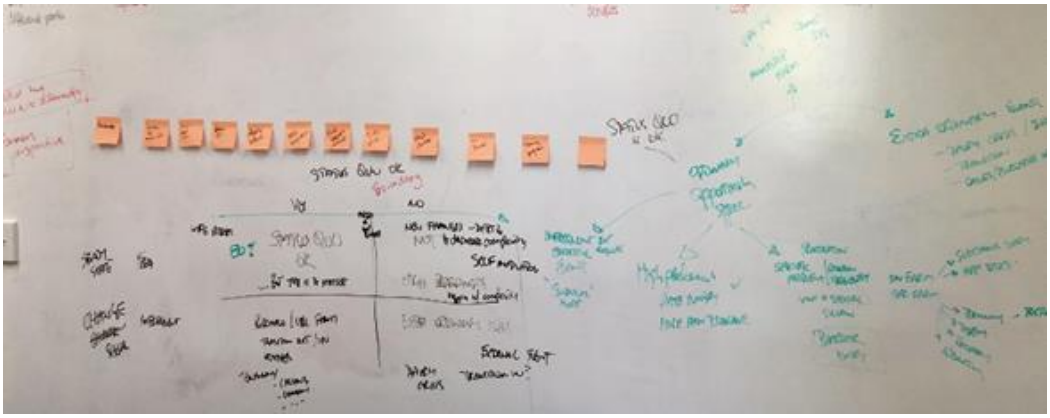

Figure 22a: Iteration 1 leading to final deliverable.

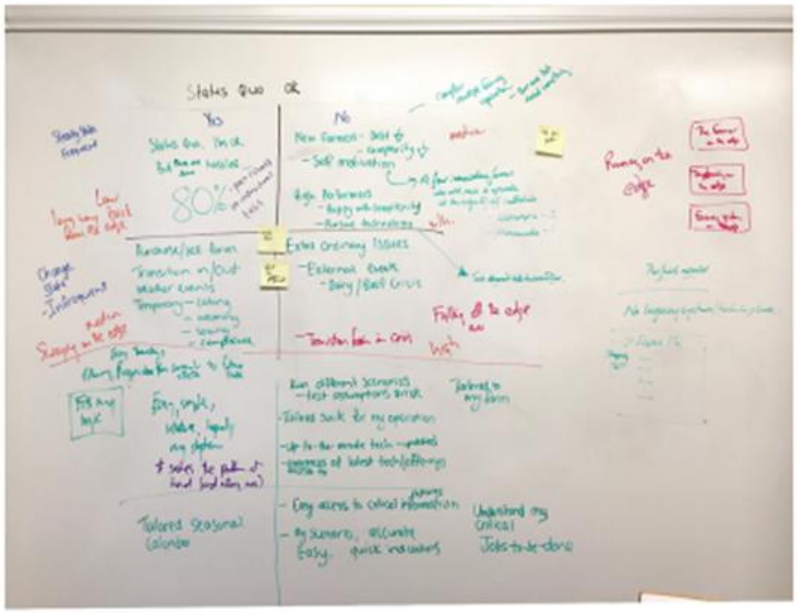

Figure 22b: Iteration 2 leading to final deliverable.

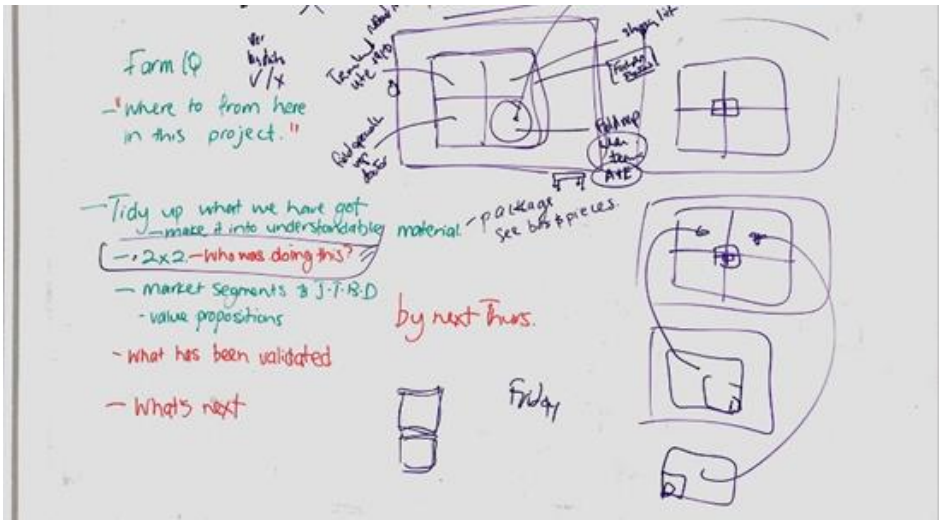

Figure 22c: Iteration 3 leading to final deliverable.

The final deliverable was framed as a 2x2 matrix, with each quadrant profiling farmers according to the different challenges they experience (see *Figure 23*). An estimated percentage of the farming population is given for each quadrant. These four quadrants require outlining in some detail in order to establish how the 2x2 matrix provides a solution for FarmIQ.

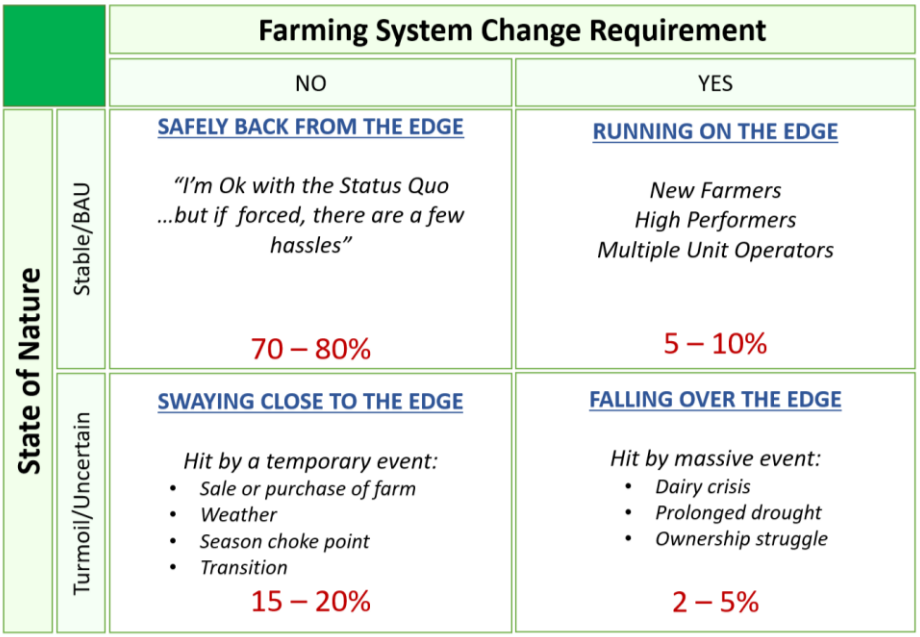

Figure 23: Farmer profiling and problem mapping, final deliverable 2x2 matrix.

To bring each of the quadrants to life, the following supplementary information is given as five scenarios.

Safely back from the edge

The farmers who are safely back from the edge are comfortable with the status quo and do not see any need to change their system requirements. However, there are occasions or events when they would like to have a short-term solution to kill a pain. The required solution needs to address the very specific pain and nothing more. Examples of such pain-creating events include seasonal activities like lambing or calving, along with episodic events such as fertilizer application and dealing with casual staff or visitors. Here, the solution offered by FarmIQ must be very easy to use and not consume any energy learning how to use it.

Swaying close to the edge

Farmers who are swaying close to the edge are affected by an event which requires time and effort to sort. The event is significant enough to cause a strong sharp pain and it needs to be resolved quickly. While events in this quadrant require a bit of effort to address, once they are fixed the farm is back to business as usual. Examples of such events are the purchase of a farm, adverse weather, regulation impacts and changes of key personnel. Farmers in this

quadrant do feel frustrated and often overwhelmed at the time of the event, but it is survivable. Such events may or may not be able to be planned for or expected and the farmer may or may not be experienced. The solution must be presented in a manner which relates to the specifics of the event or situation.

Running on the edge – New farmer

The new farmers on the edge are feeling overwhelmed and unsure about who can help them and who they can afford to pay for assistance. They are likely to put their heads down and work harder. They wish that they could find a way to make things easier, take the load off others and make better use of their own valuable time. Examples of such events are finding time for the office work while also juggling things like "I've got to move all of these animals due to unexpected weather and feed demands". The solution offered here must be basic and intuitive to use; it needs to create time, not take it away. It needs to be mobile so it can be taken everywhere. The solution must create simplicity in the system and not contribute increased. It must have the ability to be added to or scaled up.

Running on the edge – Multiple farm operator

The multiple farm operators who are running on the edge similarly find themselves juggling a diverse mix of problems. They are overwhelmed with jumping from one system to another and they wish that there was an easy way to keep an oversight over everything. They need a better way to see, evaluate and remember what is going on. They want to see when problems arise and to raise their staff up to their full potential. These farmers want a fair and equitable system that will work across all of their farms without burdening their staff. The farmers in this quadrant are highly competent and comfortable with complexity. Their difficulty arises when jumping from one system to another when these systems are all different from each other– no system is talking to another. This farmer wants a solution that aligns their overview and uses a common language and standard operating procedures. It has to seamlessly integrate into evaluation and reporting. The farmer also requires a warning system that signals where action is required in a timely fashion.

Running on the edge – High performer

High performers have a farm that is running on the edge. They know that they can push their system further, but they can't see where the opportunities for improvement are. Although the farm is already performing very well, there are always things that the farmer wants to do to push the performance higher. They know that there may be a solution out there, but if they cannot find one, they will make one up themselves. They may be running a multi-farm operation and will be doing a highly competent job. Integration will be important and so will having the ability to play with data, analysis and planning capability. Their solution must have a single point of entry and create snapshots of the entire operation. Flexibility and customization are essential to fit their operation and systems.

The above five profiles were grown out of the lengthy HCD process which kept a grounded perspective of the farmer and their JTBS's. This type of farmer segmentation helped FarmIQ to shape and target their solution offerings which became a part of their strategic planning processes and operations. It also helped to develop an MVP which created the means for FarmIQ to reach more substantial markets then they had managed prior to this HCD process.

5.6 Key differences between FarmIQ and HCD development processes

The HCD methods used in this research differed to the methods which FarmIQ used in their journey. Though the methods and key findings have been discussed above, it is useful to consider the key differences between the two approaches used. There are several areas where the HCD process "flipped" the approach used by FarmIQ. These examples include how the project outcomes were defined, the use of high and low resolution products for testing, the discovery of identifiers, remote and person to person interaction and finally the approach of building the solution compared to understanding the problem. The illustration of the key differences between the two approaches are summarised in *Table 4*.

Key differences between FarmIQ and HCD development processes	
FarmIQ process	**Design thinking process**
Project outcomes defined by the overall programme and its board and snr management)	Project outcomes defined by the user
Expressed wish list from farmers through surveys and workshops with pilot and focus groups	Interview to examine pains and gains – **expressed and latent** needs gathered then checked
Wishlist of product capabilities	Check the real JTBD
Programme outcomes defined, gather information, test – tender – build – test – (high resolution)	Gather information – test – improve – test – (low resolution)
Add on new products	Ask why
1191 user stories	8 deep dive farmer interactions
High resolution pilot product	Low resolution test product
Harder to make adjustments through iteration (high resolution problem)	Easy to make adjustments through iteration process (low resolution advantage)
Over offer packages – not much flexibility	Low resolution solution concepts – ability to scale up and add in relevant features
Job titles as identifiers	Deep dive and persona study to create identifiers
Fill out a form – interpretation risk (bias)	Face to face – check pains and gains - iteration
Build the solution	Understand the problem

Table 4: Key differences between FarmIQ and HCD development processes

In contrast, the HCD approach placed the end-user at the forefront of product and service development by consistently considering farmers during each phase of the process (Putnam et al., 2016). The HCD approach used the farmer perspectives for problem solving, making improvements and identifying opportunities by synthesising with farmers to create solutions which were viable and feasible (Dorst & Cross, 2001; Gould & Lewis, 1985; Kimbell, 2011; Price & Wrigley, 2015). The direct inclusion of farmers and the use of HCD tools and principles bridged the walls that existed between identifying, exploring, reframing and solving farmer problems, and understand their JTBD's (Cardoso et al., 2017; Giacomin, 2014; Price & Wrigley, 2015). HCD thus addressed some of the shortcomings that a heavy reliance on abstract data and quantitative analysis presented (Kimbell, 2011).

The design thinking approach allowed our analysis to go deeper than the expressed needs of farmers. Factors such as behaviour and latent needs were uncovered and often this lead to the discovery of unexpected insights which promoted the generation of further ideas and innovation, providing a more accurate reflection of the unmet needs of current and potential

customers (Carmel-Gilfilen & Portillo, 2016; Erzurumlu & Erzurumlu, 2015). During the problem identification processes, the social aspect of HCD was particularly useful when there are significant differences between what FarmIQ though it is doing to engage farmers and what the farmers wanted and needed. Such differences indicated that the organisation has not found a real and validated problem to solve (Giacomin, 2014). HCD overcame this failure through its process of problem identification and refinement, which focussed on understanding problems at a personal and contextual level (Price & Wrigley, 2015). Through the early participation of farmers in the decision making process, context and farmer circumstances were identified early and provided leading insights about what problems to progress, with the benefit of vastly reducing cognitive bias (Erzurumlu & Erzurumlu, 2015).

Through the process of clarifying the needs of farmers in a social manner, a shared vision developed. The benefit of creating a clarified and shared vision for the project meant we significantly increased team cohesion, (Lynn & Akgün, 2001). As demonstrated in the literature, care had to be taken to ensure that the vision had enough flexibility to cope with iterative nature of insights that were encountered (Lynn & Akgün, 2001; Slater & Narver, 1995). We also found that the support of the FarmIQ senior management was important and consistent with the literature. The senior management staff had a role to play in supporting and championing projects from a strategic standpoint (Lynn & Akgün, 2001). The field staff involved had a particularly important role through the project as they were in a better position to recognise opportunities at the coalface (Lynn & Akgün, 2001). One of the important outcomes from a JTBD and design thinking process, is the construction and orientation of the organisation's common understanding on what is significant and important to the customer and end-user, and then focussing the resources and energy of the organisation to align to that (Bettencourt et al., 2014). It this instance it was the farmer as the end user who co-created the final deliverables.

This thesis has accounted for the methods and principles used in a somewhat conflict free manner. However, the reality of using design thinking in teams and within organisations is that conflict is important to be aware of so that it can be managed. This was the experience in this project and will now be discussed in the next section.

5.7 Design thinking challenges

Challenges and conflict were part of the reality during this project and aligns to commentary in the literature. Indeed, this was the case when business as usual clashed with the HCD process discussed in this thesis. Clashing attributes can impact a team's performance by prompting intragroup task and emotional conflict (Pelled et al., 1999). Emotional conflict is complex by nature and is driven by interpersonal clashes that are evident through showings of negative feelings, such as anger and frustration (Pelled et al., 1999). Task conflict, on the other hand, occurs when team members disagree about job related issues such as courses of action, goals and direction or procedures (De Dreu & Weingart, 2003; Pelled et al., 1999). Emotional conflict tends to reduce team performance whereas task conflict can have a positive effect (Pelled et al., 1999). However, the latter is only true of low-level conflict that is well managed, so that the team can learn from different points of view, becoming more creative by debating ideas and confronting issues (De Dreu & Weingart, 2003). In this project, conflict was managed by the facilitator. He ensured that the level of conflict enabled healthy debate and learning to occur. Conflict issues are not overtly covered in design thinking methodology and may present challenges and blockages in effective communication among novice design thinking teams, especially during the iteration and prototyping phases (Seidel & Fixson, 2013).

It has been suggested that one of the challenges of implementing design thinking lies in the teams' composition. Team memberships may not correspond with an organisation's management groupings, posing the risk that innovative products could fall outside the borders of the organisation (Carlgren, Elmquist, & Rauth, 2016). Additionally, the culture and internal processes of the organisation may not be well placed to deal with the ambiguous nature of design thinking, which is often intensified by the different capabilities and attitudes of design team members (Callaghan, 2009).

The adoption of design thinking methodologies by novices, can pose unforeseen problems such as abandoning critical steps in the process or abandoning the process altogether, resulting in lost opportunities and lacklustre results (Seidel & Fixson, 2013). One of the traps of novice teams observing experienced design thinking teams lies in not having a full appreciation for the required skills, as these skills may not be apparent to those who are not

experienced and trained in design thinking (Seidel & Fixson, 2013). This reinforces that team member selection and composition has an effect on the success and effectiveness of projects using design thinking methodology (Seidel & Fixson, 2013). This especially so when the team is new to design thinking. It is noteworthy that less resistance is felt when formal methods are incorporated into the process (Seidel & Fixson, 2013). Teams that have the ability to be reflexive are also more inclined to adopt and use design thinking processes successfully (Seidel & Fixson, 2013). Case study analysis has found that one of the predominant challenges that faces the introduction of design thinking into organisations, is that of creating legitimacy of the methodology in the first instance (Rauth et al., 2015).

The application of design thinking can be challenging, especially as it is a relatively new concept and often tests more traditional methodology (Rauth et al., 2015). This can result in ambiguity and uncertainty for those not attuned with design thinking as a practice, or who have a lack of regard for its potential impact (Rauth et al., 2015). The measurement of design thinking methodology has drawn some attention, as the benefits and effects of projects often exceed both the project and its end date; such as the improvement of long term innovation capabilities within organisations (Rauth et al., 2015).

It can be a challenge for new design thinking participants to be comfortable with experimentation and failure; failing fast early in the process, and cheaply, ensures that mistakes are found quickly, and this provides opportunities to learn and to become more creative (Brown & Wyatt 2010).

5.8 Conclusion

This chapter has reconstructed the HCD process at FarmIQ, highlighting the results attained by each of its four phases and showing how they were progressively worked up to deliver the means to redesign the firm's software products in ways that overcame their faltering market performance. Attention here has focussed on the production of tangible outcomes and deliverables. It has also identified that challenges and conflict are areas of the overall project to be aware of and how this has to be carefully managed to effectively deal with the tension between HCD methods and the performance of the team. More than this, though, the process also reveals important learnings and observations which are material to the effective facilitation of useful design outcomes. In particular, reflection stands out as a crucial practice that warrants further consideration in its own right.

Chapter 6: Thesis achievements and reflections

6.1 Thesis achievements

This thesis has unpacked and revealed the benefits of using a human centred design (HCD) process. What makes this thesis different to many of the textbook versions of HCD is the way it demonstrates the complexity and value of working within an established organisation with a challenge that has already had considerable investment and resource applied to it. Often textbooks start with a start-up organisation or situation. In contrast, the case study undertaken here shows how HCD processes can be used to de-risk a change in strategy and substantially alter the direction of future development.

This case study has shown that HCD can be used to undertake two key jobs. Firstly, HCD is valuable for identifying the problem or opportunity for a specific organisation. The action research that underpins this thesis discovered, specified and explored the right problems that FarmIQ can solve for farmers. It also shows how HCD processes can mitigate sunk costs, preventing the expense of time, effort and resource into ideas that will not work for the end user.

The second and arguably even more important job done by HCD is its promotion of the importance of human interactions within research and development processes. This has numerous secondary effects for the organisation. As the FarmIQ case shows, HCD can unlock talent and ideas from all staff by lowering the divisions of labour and enabling socialisation in a safe haven. Such a process builds and leaves the competency with the organisation. The effects of the methodology live on beyond its use in specific projects. The intense, personal involvement of staff creates buy-in to the work and encourages follow through to results.

6.2 Reflections from the incumbent FarmIQ CEO at the time of the project

It is often the case that HCD practitioners do not get the opportunity to fully understand the organisational impact of their work. Once the product or service has been redesigned, attention moves elsewhere. To fill in this gap, on the September 28, 2021, I interviewed the incumbent FarmIQ CEO at the time of this HCD four years after this project. This reflection is provided with permission from the then CEO:

"When FarmIQ was conceptualised, there was a focus on making the boat go faster through supporting the productivity and value gains right along the value chain. We thought that this was an attractive value proposition for farmers. We gravitated towards farmers who wanted to change, but the reality was that we needed to understand a whole lot more. Our strategy was to go after the leading-edge farmers and there would be a segment of fast followers who would become clients. But they didn't. We found out that there was no clear incentive for farmers through this approach and that there was no behaviour change incentive. A lot of our tools relied on measuring animal performance, for example, weighing animals. We knew this was not the stuff that a big population of farmers actually do, but we didn't find a good way to incentivise the system.

We hadn't thought about it from a farmer adoption perspective and how to go about solving their pain points. Health and Safety wasn't that interesting, and it was thought that this wouldn't change the world, but we found out through this project that farmers wanted it. We figured out later that through partnering with other organisations, we could roll this out, meet compliance rules and make it easy for farmers.

The 2x2 matrix was about right. We were able to use that as a back-office tool to help meet our strategic requirements.

We also adopted an HCD approach to our stakeholder engagement, it became part of our stock and trade work. The project reinforced the necessity of good stakeholder engagement and customer development. HCD very much became a standard way of doing things and provided us with a method to test our intuition."

This feedback shows the value of having FarmIQ staff closely involved in the project and so gaining experience about how to use the method with farmer clients. We were able to leave this team with practical skills that they could hack and use as and when they wanted.

6.3 Post project reflections

The role of an internal champion is important. Without the support and the understanding of the FarmIQ champion, who was the CEO in this case, HCD would have been hard to implement and create traction with the FarmIQ staff.

It was also important to have the support of the external HCD facilitator. This was an essential role. The facilitator was an effective through their people leadership and experience in design. He ensured a consistent eye on the process and on the overall project. The facilitator also played a pivotal role of creating a psychologically safe haven for all of the participants to be in and for deep design work to occur.

Having large amounts of wall space was very important. It kept the workshopping processes very active and kept the participants involved. Had we not had the wall spaces, and everyone was sitting down, it is strongly suspected that it would have been very easy to have had less participation. The other advantage was that using the walls meant that the work was positioned in places where people worked side by side on the various processes. By doing this, we were able to avert people's attention to the tasks at hand and not in direct conflict with one another.

It was important to continuously keep FarmIQ involved with the evolution of interim results and relevant, actionable insights. These outputs helped to deliver communication about the processes which were being used and how the outputs were contributing to the overall outcomes.

It was important to have FarmIQ staff involved in this HCD process. It meant that they were able to buy into both the process and the outcomes. The secondary benefit was that we were able to instil new skills within the team.

6.4 The future of HCD

"Efficiency, which is doing things right, is irrelevant until you work on the right things"

Peter F. Drucker

These words by Peter Drucker serves as a reminder about what was important in this HCD project. It seems that solution focussed processes and hence linear research and development continue to rule agtech research and development. This seems to promote a hight level of comfort due to the efficiency it provides. It seems that for many, linear approaches still seems and feels so efficient as this way of working instrumentally focusses on an end which is assumed to be already known. But, if the problem you are seeking to solve is not well defined or has no owners, other than to those within the firm, then an efficiency approach will not result in long term customer adoption and market success.

Design inside any context cannot succeed as a standalone approach. It needs the support from other functions within an organisation. Through this, however, there are opportunities to build the capacity of internal teams to work together on common problems and opportunities. This is especially important in the field of agtech development. Currently, farmers and people within the food and fibre sector more generally are feeling increasingly overwhelmed with diverse pressures from a range of social groups and political regulators, as well as from those who control market access and the end-consumers of products. It has never a better time to humanise data and processes to create true value and robust solutions. This is the promising future opened up by human-centred design, both as general principles and as concrete tools. The value of this approach is the way it embeds organisational activities in the real-world experiences of end-users. Even if the entire HCD process is not adopted, there are important elements which can used anywhere and everywhere, such as empathy interviews, understanding your customers jobs and their journeys and having participatory processes to check for validity before investing heavily in final products and services.

The final words have to be, do not be tempted to abandon HCD too early. There are moments when it feels like progress has become stuck and a step forward will never happen. Iteration can seem like a repetitive circling that goes nowhere. If I always have to be learning something new, does that mean I never really know anything for sure? However, as with both the FarmIQ project and the writing of this thesis, it is important to step back, take in some fresh air, trust the process and remember why you started and for whom. Trust in the process occurs when there is trust in the people; this is what brings the breakthroughs that signal innovations worth having.

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