CRANFIELD UNIVERSITY

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CUSTOMER INSIGHTS GENERATION AT THE FRONT END OF INNOVATION: AN EXPLORATION WITHIN A MEDICAL DEVICE COMPANY

CRANFIELD SCHOOL OF MANAGEMENT

PhD

Academic Year: 2016-2023

Supervisors: Prof. Keith Goffin & Dr Richard Adams

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ABSTRACT

It is generally agreed that product innovation happens when innovation teams conduct market research to uncover customer needs. It has also been reported that customer needs and customer insights are essential for radical innovation. Over the last 40 years, research into customer needs has defined needs as either articulated or unarticulated, with associated market research methods to uncover needs and insights, such as surveys, questionnaires, observation, interviews, and a repertory grid.

Though customer needs are well-defined, customer insights need an adequate definition. Although definitions exist in the marketing and psychology literature, they are unclear or often conflicting within the product innovation field. For example, customer insights are either a separate concept from a need or a component of needs. As such, how both these concepts relate to radical innovation remains unclear. Furthermore, the process of uncovering customer needs has been well defined; conversely, the process that links the uncovering of customer needs and discovering customer insights requires an improved framework.

Nevertheless, does understanding the relationship and process between needs and insights matter and warrant being studied? If, as suggested, finding customer needs leads to incremental innovation and customer insights lead to radical innovation, then understanding this is worthwhile. This is because, firstly, for academics, investigating what innovation teams are doing during the front end of innovation (FEI) will allow them to analyse the data from case studies research more effectively. Secondly, practitioners will better appreciate the FEI process and be able to categorise their findings from market research into needs and insights, which will assist with considering the type of innovation being pursued. Therefore, understanding the relationship between a need and an insight is required. A fuller understanding of the process of discovering insights in the FEI is needed.

Through a systematic literature review (SLR) and an exploratory case study, the research attempts to investigate this conceptualisation of customer insight in product innovation and understand the relationship between needs and insights. The SLR reviewed the extant literature on the definitions of, the methods used for finding, and the

relationship between needs and insights. The exploratory case study investigated the process of discovering customer insight with innovation teams in a global medical technology company. The research had two strands – retrospective and longitudinal. Five retrospective cases were conducted immediately after the FEI had finished: four interviews per case, totalling 20 interviews. Four longitudinal cases followed the FEI for ten months; an interview was conducted with the participants at 1-, 4-, and 10-month intervals throughout the front end process; this totalled 45 interviews with 15 participants from the four cases. In addition to the interview data, documentation was also collected from all nine cases. The data was collected and analysed based on coding from the literature.

The research extends the body of literature on customer needs and insights. From a theoretical perspective, the study provides a clearer understanding of the definition of customer needs and insights. It also suggests the relationship between the concepts of need and insight. The framework proposed that discovering insights produces a better understanding of the front end process. This process is iterative, whereby finer needs are uncovered, and deeper insights are discovered as the team further understands the customer and the market research. From a practice perspective, the study assists innovation in better appreciating the interaction of needs and insights. The research also helps product innovation teams better categorise their market research findings into needs and insights that may drive more radical innovations.

Keywords:

customer needs, customer insights, front end of innovation, fuzzy front end, FEI, product innovation

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LIST OF ABBREVIATIONS

AR	Augmented Reality
BU	Business Unit
CAD	Computer Assisted Design
CASET	Case Study Evaluation Template
CIR	Customer Input Requirements
CIT	Critical Incident Technique
CNA	Customer Needs Assessment
CS	Case Study
DCI	Deep Customer Insight
DDI	Design Driven Innovation
DOC	Document
FBST	Features-Based theory of Sensemaking Triggers
US FDA	United States Food and Drug Administration
F&F	Features and Functions
FEI	Front End of Innovation
FMCG	Fast Moving Consumer Goods
GDSS	Group Decision Support Systems
GSM	Global Strategic Marketing
HCD	Human-Centred Design
ID	Identification number
IDHF	Industrial Design and Human Factors
IP	Intellectual Property
INT	Interview
ISO	International Standards Organisation
IT	Information Technology
JOC	Job Outcomes and Constraints
MBL	Market-Based Learning
MGP	Multi-Generational platform Plan
MVP	Minimum Viable Product
NM	Not Mentioned
NPD	New Product Development

PDMA	Product Development Management Association
PIM	Product Innovation Management
QC	Quality Control
QFD	Quality Functional Deployment
R&D	Research and Development
RGT	Repertory Grid Technique
RQ	Research Question
RTM	Requirements Traceability Matrix
SLR	Systematic Literature Review
SOP	Standard Operating Procedure
TPP	Target Product Profile
UoA	Unit of Analysis
UI	User Interface
UX	User Experience
VOC	Voice of the Customer
ZMET	Zaltman Metaphor Elicitation Technique

CHAPTER 1 INTRODUCTION

1.1 INTRODUCTION

This thesis delves into the process of uncovering customer insights during the front of innovation in the product innovation field. While "customer need" is well-established in the product innovation literature, "customer insight" lacks a clear definition and understanding of the necessary discovery process. Even in marketing and psychology literature, these concepts can be vague or contradictory when applied to product innovation. Therefore, this research aims to clarify the conceptualisation of customer insight in product innovation and explore the relationship between needs and insights. Specifically, the study examines how customer insights are uncovered during the front of innovation (FEI).

Firstly, a systematic literature review (SLR) was used to evaluate existing research on the definitions and methods of identifying needs and discovering insights and the interplay between the two. Then, the research used a multi-case study method to provide answers to the research questions (RQs). The nine cases were in separate business units of a single global healthcare company. The cases involved five retrospective and four longitudinal case studies. The five retrospective cases were conducted after the front end was completed: four interviews per case, totalling 20 interviews. The four longitudinal cases followed the FEI for ten months; an interview was conducted with the participants three times at 1-, 4-, and 10-month intervals throughout the front end process; this totalled 41 interviews with 15 participants across the four cases. In addition to the interview data, documentation was also collected from all nine cases. This data was then analysed, which resulted in novel findings around the front end and customer insights. This chapter will expand on this brief outline.

This introduction chapter is organised as follows:

- Overview of the systematic literature review
- Knowledge gaps
- Research methodology
- Contribution

- Structure of the thesis
- Summary of the introduction chapter

1.2 OVERVIEW OF THE SYSTEMATIC LITERATURE REVIEW

This section summarises the systematic literature review (SLR) that utilised the method proposed by Tranfield et al. (Tranfield, Denyer and Smart, 2003; Denyer and Tranfield, 2009) Conducting a comprehensive literature review at the onset of the study facilitated a complete understanding of the principles encompassing customer needs and customer insights. The systematic literature review (SLR) effectively addressed three questions.

- What is a customer need, and what is customer insight?
- What is the process whereby market research data is collected and analysed to uncover customer needs and discover customer insights?
- What is the relationship between customer needs and customer insights?

A comprehensive search was conducted to gather and assess information from various existing studies. This synthesis resulted in the proposal of definitions of a customer need and a customer insight. These refined definitions integrate the many existing definitions in the literature, effectively consolidating and streamlining the understanding of these two crucial concepts. The SLR definitions are shown in Table 1-1.

Table 1-1: Customer Need and Insight Definitions

Customer Need Definition (Section 2.)	Customer Insight Definition (Section 2.6.1)
A statement crafted by the innovation. team that interprets the market research data and defines the customer's future benefit from and value of a product's use	A customer insight is an expression of deep knowledge about customers that leads to an actionable non-obvious solution

Source: Author

The review identified three key points. Firstly, it was found that uncovering customer needs and discovering insights is located in the FEI. Secondly, the literature has

established two types of customer needs, articulated and unarticulated, and the methods available to uncover both. Thirdly, the relationship between needs and insights is not entirely clear, and the literature offers conflicting explanations. For instance, some scholars view insights as a component of needs, while others see it as a separate concept. Furthermore, only one author has examined the order of needs and insights. Table 1-2 provides an overview of the key references that motivate the research questions; the references covers areas such as the FEI.

Table 1-2: Key References for the Research

Key Reference	**Area of Relevance**
Baxter, Goffin and Szwejczewski (2014)	Customer Insights
Carlgren (2013)	Customer Needs and Insights
Cooper, Edgett and Kleinschmidt (2002)	FEI and Stage-Gate
Khurana and Rosenthal (1998)	FEI
Koen *et al. (*2001)	FEI
Price and Wrigley (2016)	Customer Insights
Weigel and Goffin (2015)	Customer Needs and Insights
Wieneke, & Lehrer (2016)	Customer Insights

Source: Author

In considering the definition of an insight, the Oxford English Dictionary (2017) defines insight as “the capacity to gain an accurate and deep understanding of something”. Yet, Smith, Wilson and Clark (2006, p. 136) stated, "Customer insight does not appear to be well defined anywhere, either by academics or practitioners”. Consequently, the term insight is mentioned frequently in the product innovation literature, but what it means is rarely stated and is often used interchangeably with customer needs (Carlgren, 2013; Baxter, Goffin and Szwejczewski, 2014).

According to the creativity literature, discovering an insight involves both problem-finding and problem-solving. On the other hand, the marketing literature views insight as a deeper understanding of a customer's needs. While creativity focuses on insight as a solution, marketing sees it as knowledge of a need. This suggests that these two insight concepts occupy different stages in the FEI process. Initially, a marketing insight is

necessary to gain a deeper understanding of the customer's wants. As the FEI progresses, the creativity definition of insight becomes relevant in finding solutions. Given that product innovation involves both marketing and creativity, using the same term for these concepts may cause confusion in the literature and practice.

The field of product innovation has a firm grasp of customer needs, but there are conflicting reports on the associated discovery process and customer insights. As a result, uncovering customer needs and discovering insights can be complicated and needs to be more researched. The definitions presented in the review work well together, highlighting the emotions, values, and benefits customers associate with a product. However, some ambiguity surrounds the relationship between these concepts, as some sources suggest that insights follow the discovery of customer needs.

1.3 RESEARCH QUESTIONS

The SLR suggested new definitions for customer needs and customer insights and confirmed that they are distinct concepts. The following two RQs have been created to address these:

RQ 1) How are customer needs related to customer insights in practice in the work of innovation teams at the front end of innovation?

RQ 2) How does the process of discovering customer insights unfold within innovation teams?

1.4 RESEARCH METHOD

An exploratory qualitative approach was employed as the research design. After reviewing philosophical perspectives, a critical realist stance was chosen, representing a middle ground in social science between positivism and constructivism. Critical realism was deemed suitable for finding the underlying relationship between needs and insight, linking with the research questions. Thus, a critical realist philosophical perspective was adopted.

Regarding data collection, an inductive multi-case study was deemed the most appropriate for exploratory research due to its ability to present evidence on a rare

phenomenon. The multi-case research had two strands to collect data, providing data from two perspectives: a retrospective and a longitudinal approach. Firstly, retrospective case studies provided a historical view of completed innovation projects and allowed the researcher to explore the process of discovering customer insights. Secondly, the longitudinal case study provided the opportunity to explore how customer insight developed during the front end of a product innovation. Additionally, a generalisable framework could be developed using cases across multiple projects. The unit of analysis is the process of discovery of customer insights within the FEI. Therefore, a multi-case study was employed to investigate the emerging phenomenon.

The case samples were chosen based on selection criteria, which included the project being an in-house development, the product innovation being sufficiently radical, and access to conduct the research being granted. A single global medical device company was used for all case studies. Data collected from the case studies consisted of transcripts from semi-structured interviews and project documentation. The retrospective study consisted of a single interview with each innovation team member, with 16 interviews in total across the four projects. The longitudinal cases consisted of three interviews with each team member over ten months and 41 interviews with 15 people. The data was analysed using the Saldana (2016) first-order and second-order coding method and the Gioia, Corley and Hamilton (2012) theory-building approach. To ensure the quality of the research, construct validity, internal validity, external validity, and reliability measures were employed, including triangulation, interview guides, and a pilot study. In addition, a cross-case analysis approach was used to aggregate the findings from each case, thus supporting generalizability.

1.5 KEY FINDINGS

1.5.1 Research Question 1

The SLR (Chapter 2) found that the current literature does not sufficiently define customer insights. It found a good understanding of customer needs, but there were contradictions with customer insights. The definitions established by the literature review complemented each other and showed the customer's underlying values and the benefits the product provides to the customer. The SLR established a clear knowledge gap

regarding the relationship between the two constructs: customer needs and customer insight. It was seen, from the reviewed literature, that customer insights have been discussed as a component of needs or a separate concept.

Additionally, the sequence of needs and insights has only been examined by one author, (Carlgren, 2013). These issues cause a problem as researchers and practitioners use the same terms but refer to different conceptualisations. The research attempted to understand the relationship between needs and insights further. Therefore, RQ 1 was developed to explore this relationship through case study research.

The findings from the research indicate that the participants possess a strong comprehension of what defines customer needs. However, they view customer insights as knowledge about the customer. After examining the definition of customer needs, all 20 participants concurred with the definition and could express a customer need in their own words. Conversely, when assessing the definition of a customer insight, the participants disagreed with the definition. While they recognised that an insight requires a deep understanding, they did not view it as creative, non-obvious, or actionable.

Regarding their relationship, the participants regarded needs and insights as distinct concepts. Twelve participants believed these concepts were separate, while ten claimed they overlap. Three participants suggested that insights are a subset of needs. When it came to the sequence of needs and insights, ten participants felt that insights lead to needs, while only two believed that needs lead to insights.

1.5.2 Research Question 2

As shown in the literature review, the process of discovering insights is a crucial element of the FEI stage. However, the current literature does not clearly describe the relationship between customer needs and insights. The creativity and marketing literature present different perspectives on the nature of insights. According to the creativity literature, insights stem from a process of problem-finding and problem-solving. In contrast, the marketing literature views insights as a deeper understanding of customer needs.

The finding showed that to understand the complex information and find meaning, various tangible design artefacts were created and used as vital communication tools at individual, group, and intergroup levels, both internally and externally. Early on,

competitors and existing products were used to understand the customer challenges and pain points. As the FEI progressed, prototypes of increasing fidelity were used to communicate to users how identified needs were being addressed. This iterative cycle produced finer-level customer insights and needs to a point where the design concept was sufficiently developed. The use of prototypes provided a focus for the conversation and enabled the exchange and combination of ideas. They came in various forms, such as physical concepts modified from existing products, 3D prints, CAD models, software wireframes, or fully functional designs representing the finished device. Crucially, they provided a route for communicating how the team interpreted insights into the product.

The study supported the future-oriented prospective sensemaking, and the data showed that the main themes of the model and the process cycles are activities that innovation teams conduct in the FEI. There was evidence to support the individual, group, and inter-group levels of sensemaking and iterative back-and-forth understanding and interpretation of new information. Sensemaking is a functional cognitive theory for interpreting and analysing how teams interact to solve complex problems and create novel solutions in the FEI. However, it only partially explains the FEI. The combination of a process framework together with the future-oriented prospective sensemaking model would provide a richer picture of the FEI.

The study found that eight case studies led to discovering insights. Further analysis showed two forms of insights in the FEI, which were determined by the type of customer engagement. The first form was insights from the initial understanding of the unmet need, and the second form was insights from the assessment of the design artefact. Customer insights were discovered through conversations, interviews, and observation of customers, while design artefacts were utilised to discuss improvements and potential design issues. The insights from the design artefacts were embodied in the subsequent design iteration, enabling teams and customers to envision the problems better.

This more precise understanding of insights in the FEI helped to clarify tensions in the literature, specifically the difference between the creativity/psychology and marketing definitions of insights, as well as the approach of product innovation management and design theories to the FEI. In the creativity literature, insight is defined as a sudden comprehension or realisation leading to a new and creative solution. On the other hand,

marketing defines insight as deep, actionable knowledge about the customers. This study identifies two forms of insight in the FEI: the marketing definition is applicable in the early stage when the team engages with the customer to understand the unmet need, and the creativity definition is relevant in the later stage when the team is finding non-obvious and creative solutions to design problems. These two forms of insight occur at different stages within the front end.

The study of customer insights in the FEI and the engagement of innovation teams in the medical devices industry has helped produce a detailed account of the FEI process. This research has improved our understanding of this complex process and has established seven front end elements across nine case studies, as shown in Chapter 10. These elements can be formed into a FEI framework. The framework provides a more nuanced understanding of how innovation teams discover insights. It contributes to the overall knowledge of the FEI process, which can help medical device innovation teams navigate the front end of the process by using the identified inputs, practices, and outputs.

In describing the process across the cases, the projects begin with a project strategy that defines an unmet clinical need. The innovation team then investigates and refines the unmet clinical need as new information is acquired, and the project strategy is revised accordingly. The other five elements interact throughout the front end process; each new piece of data changes the team's understanding. Insights are discovered using the prototype design concept, which is translated into newer customer needs. Once the technology challenges and customer feedback have been addressed, the team finalises the prototype and customer needs list, leading to the final update of the project strategy and the commencement of the NPD (New Product Development) phase of product innovation.

1.6 CONTRIBUTION

From a theoretical perspective, the investigation employs a dual-method approach to explore the discovery of customer insights through the lenses of FEI and sensemaking in medical device innovation teams. To provide a comprehensive view of completed projects, the study combines retrospective and longitudinal case studies that capture the historical evolution of the innovation process. By taking a longitudinal approach, the researcher was able to study a case at three different time points, minimising the

likelihood of recollection bias and providing a more accurate analysis of the innovation process.

In addition to exploring how insights are discovered during FEI, the research contributes to sensemaking in product innovation by investigating the cognitive aspect of discovering customer insights. By examining the cognitive processes involved in identifying and interpreting customer insights, the study provides a deeper understanding of the role of sensemaking in the innovation process.

The final contribution to theory is that the study extends the understanding of FEI by identifying additional elements and providing additional process details of the inputs, practices, and outputs of each element in medical device innovation. The study sheds light on the key elements contributing to successful innovation in the medical device industry. It provides insights into how organisations can optimise their innovation process for better outcomes.

From a practice perspective, the research findings have important implications for medical device innovators. The study identified three key areas: 1) understanding the definitions of customer needs and insights, 2) recognising the relationship between needs and insights, and 3) the process of discovering customer insights.

Firstly, it is crucial to have a clear understanding of customer needs and insights to ensure clarity within the team and with managers. By better classifying these elements, it becomes possible to categorise the type of product innovation achieved, such as radical and incremental. Gathering only customer needs can lead to incremental innovation, while discovering customer insights may lead to radical innovation. Effective communication of needs and insights is critical to success, as is the ability to classify the type of insight. Therefore, establishing a common definition for needs and insight is crucial to project success.

Secondly, understanding the relationship between customer needs and insights is essential. By constructing a story that illustrates how the final product was achieved, from market research to the marketed product, teams can better understand the flow of needs and insights. It is critical to approach market research analysis with the intention of discovering insights using various cues and triggers.

Finally, the FEI framework contributes to practice by providing a novel interpretation of the front end for medical device innovation. Careful consideration should be given to the elements, inputs, practices, and outputs rather than unthinkingly following a checklist of activities. Imposing too much control and bureaucracy on the FEI can diminish the creativity and free experimenting necessary for radical innovation.

1.7 STRUCTURE OF THE THESIS

The thesis is structured as follows:

- Chapter 2: Systematic Literature Review. This chapter discusses the SLR. It presented the context of customer needs and insight into product innovation and suggested definitions for these two concepts.
- Chapter 3: Research Design. This chapter discusses the RQs, philosophical perspectives, research methods, and theoretical perspectives.
- Chapter 4: Research Methodology. This chapter considers the research approach, unit of analysis, sample selection and the data analysis approach.
- Chapter 5: Feasibility Case Study: This chapter presented the feasibility case study data collection, analysis, and results.
- Chapter 6: Pilot Case Study: This chapter presents the pilot retrospective case study data collection, analysis, and results.
- Chapter 7: Findings for RQ 1: This chapter presents the findings for Research Question 1 for the four retrospective case studies.
- Chapter 8: Findings for the Retrospective Case Studies: This chapter presents the within-case results and conclusions of the four retrospective case studies.
- Chapter 9: Findings for the Longitudinal Case Studies: This chapter presents the within-case results and conclusions of the four longitudinal case studies.
- Chapter 10: Cross-Case Analysis for RQ 2. This chapter presents the findings of the cross-case analysis based on the nine case studies for RQ 2.

- Chapter 11: Discussion and Conclusion. This chapter considers how the research addresses the knowledge gaps. It also presents the findings and the theoretical and managerial implications.

1.8 SUMMARY OF INTRODUCTION CHAPTER

This chapter presented a concise introduction to the significance of researching customer needs and insights into product innovation. An SLR was conducted to identify knowledge gaps, which led to the formulation of two RQs. The multi-case study research design, case selection, and data analysis approach were also outlined.

CHAPTER 2 SYSTEMATIC LITERATURE REVIEW

2.1 INTRODUCTION

Chapter 2 presents the results of the SLR on customer needs and customer insights within product innovation. The SLR used the method proposed by Tranfield and colleagues (Tranfield, Denyer and Smart, 2003; Denyer and Tranfield, 2009). Reviewing the literature at the start of the research allowed a deeper understanding of the concepts of customer needs and customer insights.

Insight, often referred to as the 'aha moment', has generated many stories. One of the most well-known stories is of Archimedes. Archimedes was trying to solve the problem of measuring the gold content of the king's crown when he realised that water displacement could be used to measure volume and thus calculate the crown's density - the now famous 'Eureka' moment (Sprugnoli *et al.*, 2017). The Oxford English Dictionary (2017) defines insight as "the capacity to gain an accurate and deep understanding of something". Yet, Smith, Wilson and Clark (2006, p. 136) stated, "Customer insight does not appear to be well defined anywhere, either by academics or practitioners". Consequently, the term insight is mentioned frequently in the product innovation literature, but what it means is rarely stated, and it is often used interchangeably with customer needs (Carlgren, 2013; Baxter, Goffin and Szwejczewski, 2014).

The SLR process searched and synthesised existing studies. This synthesis proposed new definitions of customer needs and customer insight that integrate the variety of existing definitions in the literature. How the two concepts are related in product innovation needs to be clarified; some publications suggested that discovering insights follows the uncovering of customer needs, but this needs to be fully substantiated. This phenomenon requires further research; filling this gap will provide a foundation for the empirical phase of the research.

Chapter 2 is organised into the following sections:

- Introduction to product innovation
- Needs and insights in context

- SLR methodology
- Customer needs
- Customer insights
- Uncovering customer needs
- Discovering customer insights
- Relationship between customer needs and insights
- Discussion and conclusion
- Proposed research questions
- Summary of systematic literature review

2.1.1 Overview of Literature Reviews

Throughout the research study, literature reviews were conducted at different time points. The first review, conducted between 2017 and 2018, was the original review. Following a 5-year gap since the original review was conducted, a second literature review (SLR) was conducted to cover the years from 2019-2023, using the same methodology as stated in Section 2.4 and the same search strings (Section 2.4.2) across four electronic databases (EBSCO, ABI/Proquest, PsycINFO and Scopus). The findings from the updated SLR have been integrated into the original review. The SLR process and papers are available in Appendix A.6 and A.7. A third literature review was conducted in November 2023 on the front end to better understand FEI theories and strengthen the theoretical contribution of the research findings, as discussed in Section 2.2.3 (with results available in Appendix A.8). A third review of the AI landscape in customer insights was conducted, with the results found in Section 2.9.

2.2 INTRODUCTION TO PRODUCT INNOVATION

The two concepts of customer needs and customer insights are contextualised within the overarching theory of *product innovation management*. Product innovation is defined as the process of developing and commercialising new products. It consists of the creation of a new idea and then developing that idea into a product for commercialisation

(Frederiksen and Knudsen, 2017). Roberts (2007, p. 6) defined this with a simple equation: "Innovation = Invention + Exploitation". Product innovation occurs after the market discovery stage; this is where a company works on upstream activities to find new markets for either existing or new products and services (Bower and Christensen, 1995; Goffin and Mitchell, 2005). As such, the market discovery phase is outside the scope of this thesis.

Innovation teams looking for a competitive advantage must drive product innovation by engaging with customers. Innovation teams that do not effectively engage their customers may have an increased chance of developing an unsuccessful product (Cooper, 1999). Innovation teams that engage customers can increase their ability to identify customer needs and insights, leading to a successful product (Goffin *et al.*, 2012).

It has been established that understanding *customer needs* and *customer insights* leads to successful products (Cooper and Kleinschmidt, 1987; Griffin and Page, 1996). For example, Cooper and Kleinschmidt (1987) offered that "having customers' needs, wants, preferences and product requirements well defined prior to product development" significantly impacts financial performance. The Oxford English Dictionary (2017) defined a customer need as "circumstances in which something is necessary, a thing that is wanted or required". Also, it stated that customer insight is "the capacity to gain an accurate and deep understanding of someone or something". Consequently, to improve the odds of designing and developing a successful product, innovation teams conduct market research and analyse the market research to uncover customer needs and discover customer insights (Elfvengren *et al.*, 2004).

The literature suggested that both concepts, i.e., customer needs and customer insights, play an essential role in product innovation. However, there appears to be a gap in the literature as neither the relationship between needs and insights nor the insight discovery process is clearly defined. This gap matters in product innovation. Firstly, having a clear understanding of the relationship between needs and insights will assist innovation teams in having a clearer understanding of market research. Secondly, teams will have a better understanding of the process and, as such, be more effective in discovering insights.

The following section describes where customer needs and insight sit within the product innovation theory. The following section then illustrates the systematic review method. The third section provides a descriptive analysis of the systematic review results. The fourth section covers the central review and analysis of the publications, including definitions of needs and insights, how customer needs are uncovered, and how insights are discovered. The final section presents future research directions and the conclusion.

2.2.1 Thesis within the product innovation context

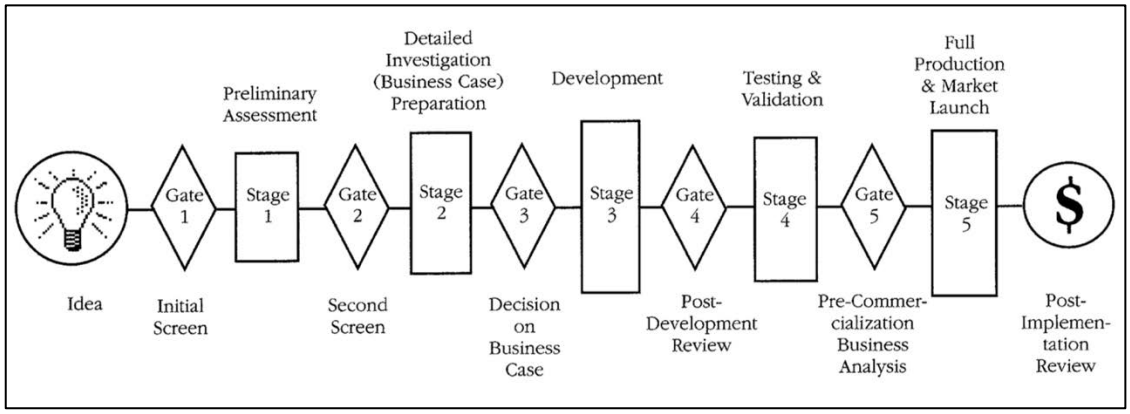
As stated, the research into customer needs and insights sits within the FEI phase of product innovation. Many related activities occurred prior to the FEI, such as market discovery, invention, scientific discoveries and fundamental scientific research. The research does not explore the insights reported in these areas. Furthermore, the research does not cover the processes that occur after the FEI, such as new product development (NPD), diffusion of innovation, product lifecycle management or market development.

2.3 NEEDS AND INSIGHTS IN CONTEXT

2.3.1 Overview of Product Innovation

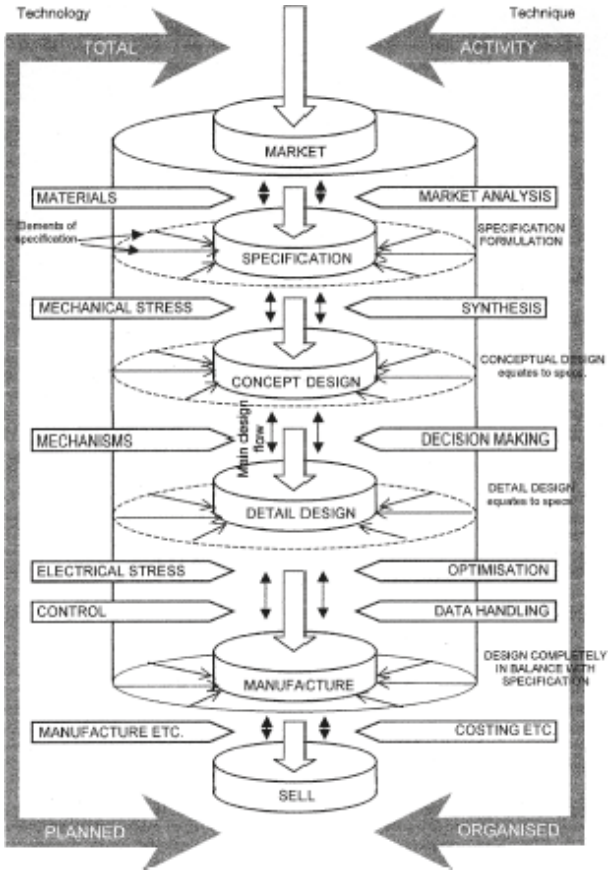
Product innovation represents the core renewal process for a company, and it is "driven by the ability to see connections, to spot opportunities and to take advantage of them" (Tidd, Bessant and Pavitt, 2005, p. 4). Garcia and Calantone (2002, p. 112) described product innovation as "an iterative process initiated by the perception of a new market or new service opportunity for a technology-based invention which leads to development, production, and marketing tasks striving for the commercial success of the invention". Furthermore, innovation is recognised as a "multi-stage process whereby organisations transform ideas into new/improved products, services or processes, to advance, compete and differentiate themselves successfully in their marketplace" (Baregheh, Rowley and Sambrook, 2009, p. 1334). Mascitelli (2000, p. 181) stated innovations that "are unique, original, and unexpected are far more valuable from a competitive standpoint than innovations that are predictable, incremental and mundane". The process of uncovering needs and insights sits within the initial stages of the product innovation process.

Figure 2-1: Stage-Gate System



Source: Adapted from Cooper (1990)

Figure 2-2: Total Design Method



Source: Adapted from Pugh (1991)

Numerous authors have discussed the process of product innovation. Key authors on this subject are Pugh (1991) with the Total Design model and Cooper (1990) with the Stage-Gate model.

Figure 2-3: Stage-Gate Model with Discovery Stage

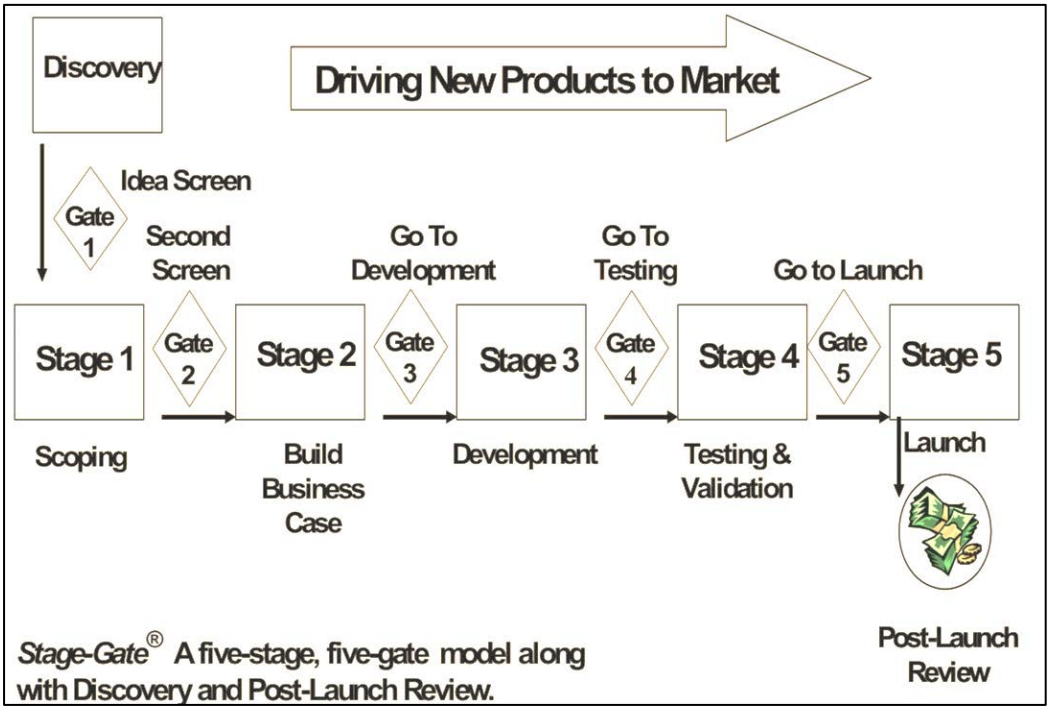


Figure 2-2 shows the Pugh Total Design model, and Figure 2-1 shows the Stage-Gate model. According to Google Scholar, Pugh has been cited over 2300 times, and Cooper 1900 times. Although the models differ regarding functional orientation, the stage-gate process is market-oriented, whereas the total design model has an engineering design orientation. These authors described a similar model with multiple development stages and managerial review gates. A stage is when development work is accomplished by the cross-functional product innovation team, typically consisting of design, engineering, marketing, and production. A gate is the quality review whereby management approves the completed work. In the last few decades, the broad adoption of these models "has enabled companies to better manage their overall product innovation process" (Cooper, Edgett and Kleinschmidt, 2002, p. 22). However, these models did not consider early customer engagement.

To address the early customer engagement phase, Cooper, Edgett and Kleinschmidt (2002) augmented their existing model with an initial front end discovery phase, followed by the product development phase (Creusen, Hultink and Eling, 2013). Figure 2-3 shows the revised stage-gate model with the addition of the discovery phase. Different activities

occur in the early phase of product innovation, so it was essential to differentiate this from the product development phase (Veryzer and De Mozota, 2005).

Ulrich and Eppinger (2015) took this idea further referring to the front end stage as exploration. In this exploration stage, the team engages customers to uncover customer needs and discover unique customer insights. The discovery or exploration phase is now more commonly referred to as either the Fuzzy Front End (FFE) (Koen *et al.*, 2001) or the Front -End of Innovation (FEI) (Reinertsen, 1999; Eling and Herstatt, 2017). As Koen *et al.* (2001, p. 46) suggested, the FEI will be used instead of Fuzzy Front End, as fuzzy "implies that this portion of the innovation process is mysterious…unknowable and uncontrollable". Although the general purpose of the product innovation process is well understood, bringing an invention to commercialisation, the FEI is fuzzy and less well understood than NPD but "presents one of the greatest opportunities for improving the overall innovation process" (Koen *et al.*, 2001, p. 46). The practice of uncovering customer need and discovering insights is firmly situated in the FEI (Krishnan and Ulrich, 2001; Rejeb, Boly and Morel-Guimaraes, 2011; van den Ende, Frederiksen and Prencipe, 2015; Frishammar *et al.*, 2016).

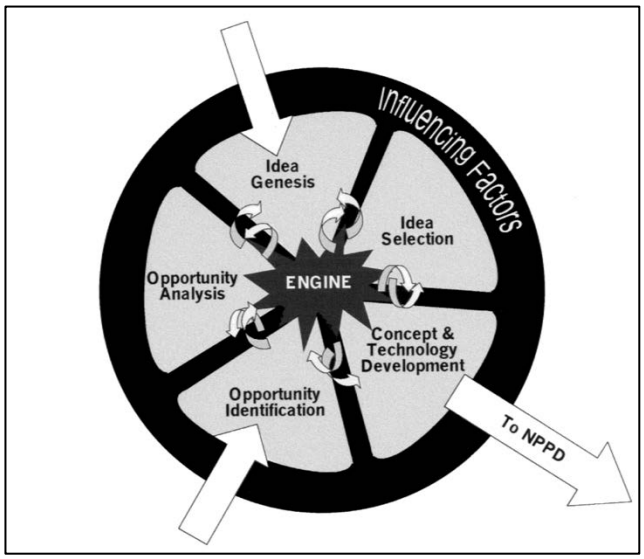
It is recognised that employing an effective FEI process is essential for developing either incremental or radical products (Cooper and Kleinschmidt, 1987). Khurana and Rosenthal (1997) defined the FEI as a linear process, which includes establishing the product strategy, market requirements, development plans and product concept the process is shown in

Figure 2-5. In the New Concept Development Model (Figure 2-4), Koen *et al.* (2001) conceptualised the front end as a circular flow that is fuzzy, random and non-sequential, where all elements are continuously influencing each other, characterising the front end as containing the key elements of opportunity identification, opportunity analysis, idea genesis, idea selection, product concept and technology development. Though the Khurana and Rosenthal (1997) and Koen *et al.* (2001) models have contrasting linear and circular flows, it is important to note that both authors reported that fluidity and looping back to prior activities is essential. When new knowledge is discovered, the innovation team reappraise their current understanding of the problem and possibly changes the direction (Koen *et al.*, 2001). The various FEI models differ in how the information flow

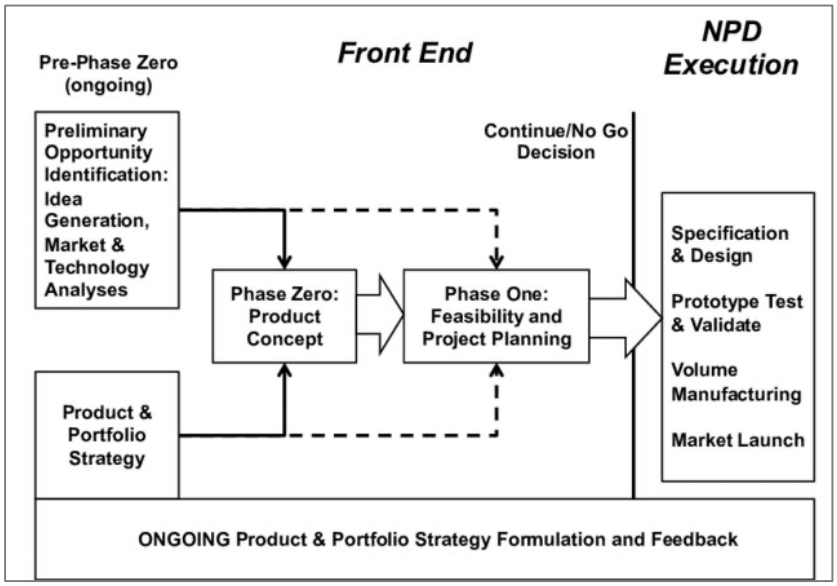
is shown. For example, certain activities are similar, firstly a market research stage where the team explores the opportunity by engaging with the customer, and an analysis stage where the team interprets the market research data to uncover customer needs and discover customer insights (Creusen, Hultink and Eling, 2013).

The design process has also been researched to understand how this activity is involved within the FEI. Design and its associated theories emerged from design agencies as practices that comprised both market research, mainly observation, and interviews(Leonard and Rayport, 1997; Veryzer and De Mozota, 2005; Brown, 2008). A key aspect of these design theories was the early and continuous engagement of customers in the FEI. These theories will be discussed later in this chapter.

Figure 2-4: The New Concept Development Model



Source: Adapted from Koen et al. (2001)



Source: Adapted from Khurana and Rosenthal, 1997

Product innovation can take many forms. So, it is also important to understand the various innovation types that have been reported. In attempting to describe the range of innovations, authors have proposed various terms. Innovations have been classified from simple product changes of existing designs to products that have a profound impact on the company and society (Garcia and Calantone, 2002). The four main innovation types in the literature are: 1) *incremental* versus *radical* (Gatignon *et al.*, 2002; Norman and Verganti, 2012), 2) continuous versus discontinuous (Veryzer, 1998), 3) sustaining versus disruptive (Bower and Christensen, 1995; Danneels, 2004) and 4) breakthrough innovation (Mascitelli, 2000). Incremental innovation refers to building on existing technology and performance characteristics to provide improved benefits to the customer in existing established markets (Garcia and Calantone, 2002; Gatignon *et al.*, 2002) In contrast, radical innovations embody new technology that results in the creation of a new market (Garcia and Calantone, 2002) which provides a novel solution that fulfils unmet customer needs and provides new benefits (Danneels and Kleinschmidt, 2001). It has been suggested that the depth of understanding of customer needs has a relationship with the type of innovation (Goffin *et al.*, 2012). By gaining a deeper understanding of customers, an innovation team can uncover unmet customer needs.

2.3.2 Overview of Customer Needs and Insights

The following section will provide an overview of the customer need and customer insights. In their seminal paper on the *voice of the customer (VOC),* Griffin and Hauser (1993) stated that "customer needs are the problems that a product or service solves and the functions it performs. Needs describe 'what products let you do, not how you do it'" (Griffin and Hauser, 1993, p. 4). VOC proposed that customers should be directly engaged by the innovation team (Cristiano, Liker and White, 2000; Bharadwaj, Nevin and Wallman, 2012). However, there has been criticism of VOC; researchers have stated that using the directly articulated VOC statements gathered through interviews, surveys, and questionnaires has led to the development of incremental products (Verganti, 2009; Norman and Verganti, 2012). This is because customers speak in the language they are familiar with; referencing today's solutions and features, customers become fixated on how products are currently used and the issues they have now (Patnaik and Becker, 1999; Goffin and Lemke, 2004; Hentschel, 2009; Goffin *et al.*, 2012).

For radical innovation to happen, innovation teams must move away from VOC to newer techniques to uncover unarticulated customer needs (Ulwick, 2003). It has been proposed that this is because radical innovation comes from unexpressed, hard-to-find needs, as these are difficult for competitors to copy, thus providing market differentiation (Ulwick, 2003; Narver, Slater and MacLachlan, 2004). So, researchers turned their attention to studying techniques that attempt to uncover the unarticulated needs, such as ethnography and the repertory grid technique (RGT) (Karkkainen and Elfvengren, 2002; Goffin and Lemke, 2004; Baxter, Goffin and Szwejczewski, 2014). Consequently, there remains a tension between the articulated VOC needs and the unarticulated hidden needs. Though both drive product innovation, researchers have asserted that hidden needs drive radical innovation, whereas VOC only drives the less valuable incremental innovation (Ulwick, 2002; Goffin and Lemke, 2004).

In addition to uncovering customer needs, the process of discovering customer insights has also been recognised as a valuable capability (Said *et al.*, 2015; Price and Wrigley, 2016), as it is a source of competitive advantage (Zaltman and Coulter, 1995; Wills, 2005) and essential for radical innovation (Weigel and Goffin, 2015). Research into customer insights has been traditionally centred in the fields of psychology and

marketing, but recently the product innovation field has shown increased interest (Henderson, 2011; Hamilton, 2016).

The psychology literature has defined insight as “the reinterpretation or restructuring of a problem to reveal a new, often simple, solution” (Kounios and Beeman, 2014, p. 73). The marketing literature defined a customer insight as “deep, embedded knowledge about the customers and the market around us that helps structure thinking and sound decision-making” (Wills, 2005, p. 304). Both marketing and psychology have established definitions of insights, but product innovation has not. Therefore, if the discovery of customer insights drives radical innovation, the product innovation field requires better definition and understanding of the process of the discovery of customer insights.

The preceding sections situated the research in the product innovation context. Uncovering needs and discovering insights are part of the FEI phase of the product innovation process. The next sections will explain the SLR method used to find the relevant publications. Then will discuss the definitions of needs and insights in the literature, how needs are uncovered, and insights discovered, and finally how these two concepts relate.

2.3.3 Theoretical Background of the Front End of Innovation

The front end of innovation was briefly introduced in Section 2.3.1, Overview of Product Innovation. The literature on the FEI lays out a theoretical framework that informs the research. The following section discusses its historical evolution, the foundational models, and contemporary frameworks.

The FEI is the earliest stage in innovation and has gained significance since the late 1980s. Reinertsen (1999) described it as a "Fuzzy Front End", Cooper (1990) and Khurana and Rosenthal (1997) highlighted its crucial role in shaping innovation. They proposed that the FEI is about more than just generating ideas. It is a strategic point where organisations align their innovation efforts with broader business objectives and market needs. The evolution of FEI models from linear to more iterative and flexible frameworks reflected the growing understanding of its complexity. FEI holds the key to efficient resource allocation and impactful innovation outcomes despite its ambiguity (Brun,

Steinar Saetre and Gjelsvik, 2009; Pereira, Ferreira and Lopes, 2017). The FEI is where the market research activities (discussed in Section 2.7) to understand the customer occur (Creusen, Hultink and Eling, 2013).

Koen *et al.* (2001) introduced the term "Front End of Innovation" as a substitute for the 'Fuzzy Front End' because fuzzy implied that the front end is mysterious, lacks accountability, and cannot be managed. From earlier studies (Cooper, 1988; Moenaert *et al.*, 1995; Khurana and Rosenthal, 1997) to more recent ones (Markham, 2013; Koen, Bertels and Kleinschmidt, 2014a; Koen, Bertels and Kleinschmidt, 2014b; de Oliveira *et al.*, 2015), researchers have identified key issues and proposed best practices. Consequently, the FEI field has expanded to include numerous research themes and topics.

To improve an organisation's innovation activities, its early stages offer the most significant potential for effectiveness and efficiency (Florén and Frishammar, 2012). The FEI consists of activities before the formal innovation process, including strategically oriented activities such as opportunity identification and analysis and more operational processes like ideation and concept development. While some models begin with an idea generation phase, most start with a more strategically oriented initial scanning process, followed by opportunity identification and analysis (Zhang, Cao and Doll, 2019).

Cooper proposed the Stage-Gate process (Cooper and Edgett, 2008), this process encompasses the FEI and the NPD phases. Over time, the model has been improved by integrating lean and agile approaches (Cooper, 2016). Khurana and Rosenthal (1997) identified the critical role of organisational strategy as a driving force in the innovation process. The authors proposed a model that links business and product strategy. They emphasised the importance of a well-planned portfolio, an enabling organisational structure, identifying customer needs adequately, and developing a well-defined product concept for successful NPD.

The models proposed by Cooper, and Khurana and Rosenthal are linear schemes. Over the years, Cooper's model has evolved and gained an iterative nature. In turn, Koen *et al.* (2001) designed a model with a fundamentally iterative nature, attempting to address the complexity of this phase.

Koen *et al.* (2001) created the New Concept Development (NCD) Model to establish a common language. The NCD model is distinct from other FEI models because

it introduced a non-linear approach by adopting a circular process. It also emphasised the importance of external and internal influences on the process flow. The work aimed to provide methods, tools, and techniques, although these tools are likely to be selected and used in a heuristic manner. The NCD Model consists of three essential parts: the engine, the controllable activity elements, and the influencing factors. The engine relates to leadership, culture, and business strategy. The controllable activity elements (inner parts of the model) include opportunity identification, opportunity analysis, idea generation and enrichment, idea selection, and concept definition. Lastly, the influencing factors are those related to the internal and external environment, namely organisational capabilities and the outside world. According to the authors, these factors may influence the entire innovation process.

Koen, Bertels and Kleinschmidt (2014a); (Koen, Bertels and Kleinschmidt, 2014b) validated and extended their model in a three-year study. They found that opportunity identification and analysis, idea enrichment, and concept definition were the most critical activity elements for success in incremental innovation. In contrast, practical elements for radical innovation were related to understanding existing and disruptive markets and leveraging new and emerging technologies. The study emphasised the importance of embedded market and technology competence in radical innovation efforts. This is because radical innovation may require defining a new or emerging market, and identifying technology that can provide solutions for that new market. Therefore, radical innovation requires a deep understanding of emerging markets and relevant technology. From these initial frameworks, research into the FEI has grown recently. Pereira, Ferreira and Lopes (2017, p. 35) stated that 'evidence shows that the FEI has received greater attention in recent years regarding depth and number of publications'. Furthermore, a 'high number of publications related to tools and methodologies. Although these works bring some insights to the field, most of the contributions address the effect that a specific tool has on a particular FEI process. There is a lack of contributions regarding the so-called process activity models (mapping the entire FEI process)'.

The next part of this theoretical review will explore other frameworks that have been proposed; refer to Appendix A.9 for figures of the FEI frameworks discussed below. Nobelius and Trygg (2002) identified six elements of the FEI process that contribute to identifying an opportunity: mission statement, concept generation, concept screening,

concept definition, business analysis, and project planning. The authors noted that the FEI process can vary significantly depending on the type of project, including the activities, sequences, degree of overlap, time required, and importance of individual tasks. Therefore, it is essential to remain flexible in structuring FEI models.

Few studies have identified current practices in healthcare industries. Evidence suggests that innovation teams in the health industry face unique hurdles or barriers. Innovators need to evaluate increasingly complex regulatory and reimbursement environments. There are often multiple stakeholders, including the patients, the clinicians, and the payers. Technical uncertainty is also often more significant due to the unpredictability of biological systems and extensive performance testing that typically needs to be conducted. These models do not always predict product performance, biocompatibility, and safety in the human body, which compounds the technical risks. (Vagn Jensen, Clausen and Gish, 2018)

Trotter (2011) investigated a multinational Global Healthcare Company and proposed the Total Front End Framework (TFEF) for Transformational Innovation. The study validated existing FEI theories and highlighted that even innovative companies can improve how they innovate. The study proposed new optimal team structures, processes, and activities that should be conducted to ensure that high-value opportunities and ideas are selected and progressed into NPD.

In a retrospective multi-case study, Vagn Jensen, Clausen and Gish (2018) proposed three perspectives on managing FEI: a process model, a knowledge perspective, and a translational perspective. While the process models used in managing FEI activities are often seen as problematic, several strategies have been developed to complement these models. These strategies focus on sourcing, sharing, and creating knowledge with those involved in FEI activities. They view innovation not as a linear process but as an interactive knowledge process where knowledge exchange occurs. This perspective offers an informal response to the limitations of process models. The translation process involves conceptualisation and network recreation. It highlights that the content and intentions of FEI activities are more critical than the formalities and forms of collaboration.

Chang, Chen and Wey (2007) conceptualised the concept of FEF (Front End Fuzziness). This included varying levels of uncertainty, complexity, equivocality, and variability. FEF was extended to include its sources, categorised as front end environment, front end means, and front end goals. This helps innovators quantitatively assess the level of FEF and determine how and where a project has more fuzziness than other alternatives. The effectiveness of a framework can be measured by how well it assists organisations in handling the influx and outflow of technology. In a

In an analysis of 266 front end published studies Park, Han and Childs (2021) found ten criteria divided into two dimensions. The first dimension consists of six criteria associated with the overall attributes of FFE, including the study taxonomy, model type, NPD speed, NPD attributes, model characteristics, and model structure. The second dimension is relevant to performance related to process parameters, comprising four criteria: the FFE task, activity, performance method, and toolkit. The paper formulates an FFE model development strategy for each criterion based on this identification.

Appio *et al.* (2013) examined the activities of opportunity identification and opportunity analysis. Managers of the innovation team have the ability to use several tools to facilitate and optimise decisions. To determine the most appropriate tool, managers must consider various options, including the dimensions influencing the decision-making process and how those tools impact performance metrics. They found no correlation between awareness of basic requirements for tool usage and dimensions such as effectiveness, difficulty of use, frequency of use, and estimated investment.

Contrary to current literature, Zhang, Cao and Doll (2019) argued that equivocality, rather than uncertainty, is the primary cause of front end issues. This emphasises the importance of team vision as a front end deliverable. The authors have identified team vision as a critical front end deliverable and have developed a framework to support it.

Frishammar and Lichtenthaler (2013) suggested that the path from the surfacing of new product ideas to product definitions presents numerous obstacles and managerial challenges that must be addressed if a firm is to become successful in front end activities. The article provides a framework and advice to guide managerial decision-making and support managers in dealing with incremental and radical innovations.

Kim and Wilemon (2002a); (Kim and Wilemon, 2002b) defined the FEI as the period from when an opportunity is first considered to when an idea is assessed as ready for development. They categorised the outcomes into three dimensions: product definition, time, and people. To manage the FEI, they suggested employing several strategies, such as assigning an FEI manager or team, offering organisational support, comprehending the sources of ambiguity, building an information system, and developing relationships with supporters, partners, and alliances (Kim and Wilemon, 2002b).

Two studies focused on ambiguity, in a study of the health care industry Brun, Steinar Saetre and Gjelsvik (2009) presented a model that classifies ambiguity along two dimensions: subject and source. The subjects of ambiguity include product, market, process, and organisational resources. At the same time, the sources of ambiguity include diversity, novelty, validity, and reliability. Gama *et al.* (2022) analysed how firms managed the development of ideas at different levels of ambiguity. The study suggested that the appropriate sets of capabilities are crucial to developing product definitions. Based on a multiple case study of seven manufacturing firms, the study proposed a capability-based contingency framework for harnessing front end ambiguity. The findings highlight the importance of assessing ambiguity levels at the initial stage and following specific exploratory and exploitative capability paths, depending on the nature of the idea and concept under development. These results are significant in idea and concept development, where maintaining a competitive advantage is crucial.

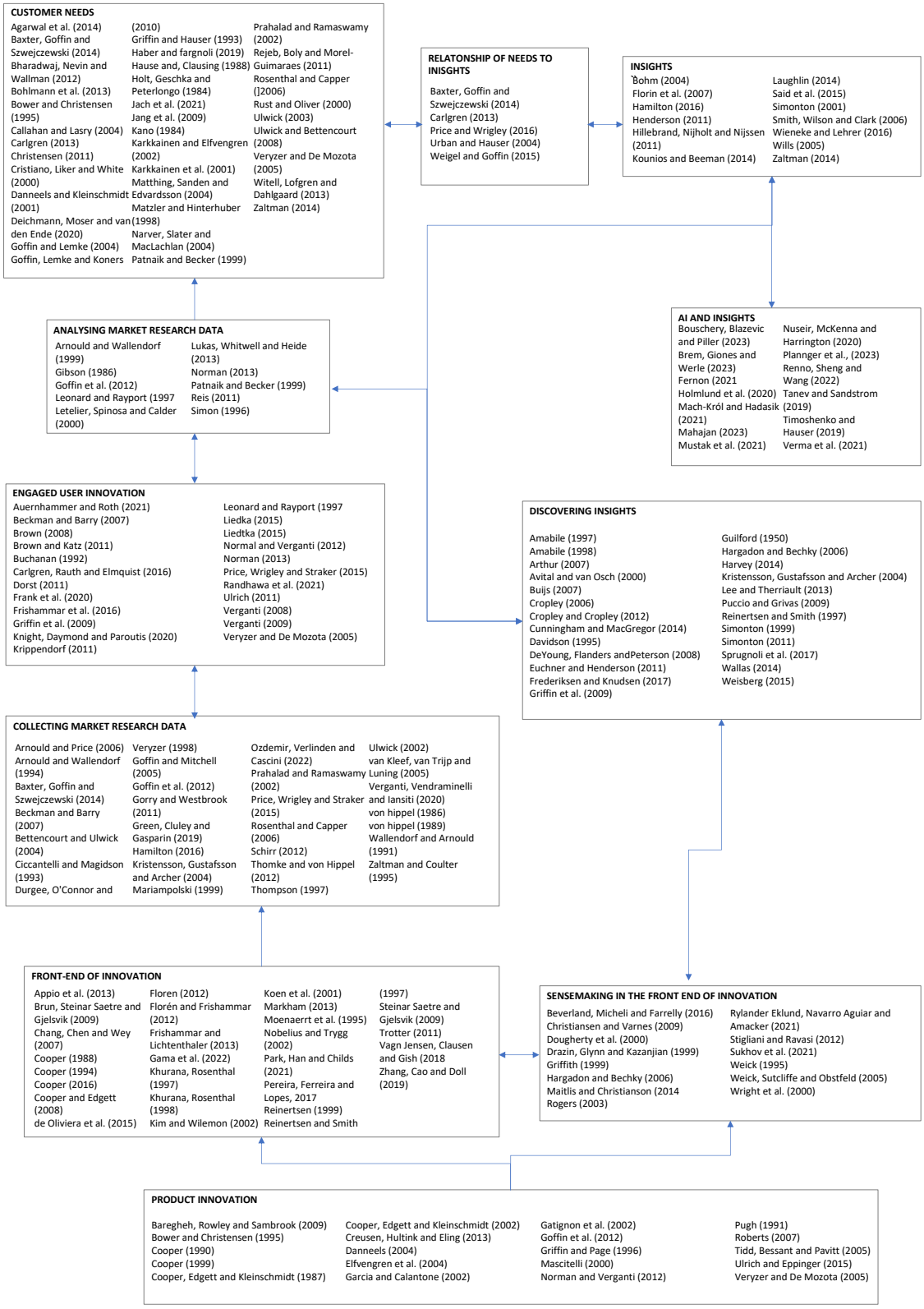
The FEI is a constantly changing and dynamic area. It used to be seen as an unclear initial phase of innovation, but it has become a crucial strategic process shaping the entire innovation pathway. The shift from linear models like Cooper's Stage-gate process to more nuanced frameworks like Koen et al.'s New Concept Development Model shows a deeper understanding of FEI complexities. Incorporating agile methodologies further demonstrates the ability to adapt to rapidly changing markets and technological landscapes. Research in different fields, particularly healthcare, has highlighted FEI's importance in navigating complex regulatory environments and addressing diverse stakeholder needs. The development of frameworks such as the Total Front End Framework and capability-based contingency models indicates a move towards more holistic and flexible approaches to managing FEI (the frameworks discussed can be found in Appendix A.8). Future research and practice in FEI should aim to integrate these

various models and insights to create more robust and adaptable frameworks that can cater to the different needs of multiple industries and innovation types. This will help organisations leverage FEI's full potential to drive successful and sustainable innovations.

2.3.4 SLR Theoretical Framework

A visual representation of the literature in this review can be found in Figure 2-6 below. The figure shows the main areas that have been discussed in the following SLR. The figure begins with product innovation and continues up into the front end of innovation and sensemaking. The framework shows that there has been research into the collection and analyses of market research, and customer needs. The discovery of insights has been mainly focused on the creativity literature. However, it is clear that needs and insights have been investigated, empirical research into relationship is between these two concepts is lacking.

Figure 2-6: SLR Theoretical Framework



2.4 SLR METHOD

An SLR was undertaken using the methods proposed by Tranfield and colleagues (Tranfield, Denyer and Smart, 2003; Denyer and Tranfield, 2009). This method was originally developed in the field of medical science as a comprehensive means of locating publications and synthesising the published evidence on a particular healthcare intervention (Counsell, 1997). The method is intended to "bring a replicable, scientific, transparent approach" (Denyer and Tranfield, 2009, p. 672) to allow future researchers to replicate the literature review. An SLR requires searching and selecting relevant literature on a subject. The five steps involved are: 1) question formulation, 2) data collection, 3) selection and evaluation, 4) analysis, and 5) synthesis. Steps 1, 2 and 3 are described below. Step 4 is contained in the descriptive analysis section; Step 5 makes up the main body of the SLR.

2.4.1 SLR Questions

This review focused on customer needs and customer insights during product innovation. The review attempted to 1) clarify the definitions of customer need and insight, 2) review how needs and insights related to each other, and the methods used for uncovering them. Accordingly, this SLR addresses three questions:

- What is a customer need, and what is customer insight?
- What is the process whereby market research data is collected and analysed to uncover customer needs and discover customer insights?
- What is the relationship between customer needs and customer insights?

2.4.2 Data Collection

Data collection consisted of five steps, beginning with defining the keywords and search strings. The keywords used in the search strings were identified through an initial scoping of the literature. The search strings were broad to ensure relevant published publications were found. Therefore, terms such as product innovation, NPD (new product development), and front end were not included as these may have limited the results.

Eight keywords and phrases were used to construct the search strings (Bakker, 2010). Finally, the two searches were conducted separately using the following search strings:

1. "Customer need*" OR "customer insight*" OR "voice of the customer" OR "customer voice" OR "product insight*" OR "consumer insight*" OR "consumer need*"
2. Creativ* AND insight*

The titles and abstracts of peer-reviewed journal publications were searched in four electronic databases: EBSCO, ABI/Proquest, PsycINFO and Scopus. A total of 13,015 publications were returned; Search string 1 returned 7,227; Search string 2 returned 5,788. After removing duplicates using the Microsoft Excel function, the total was 9,384. Refer to Figure 2-7 for a pictorial representation of the literature selection process. To ensure the review was able to capture this diversity, all peer-reviewed publications and relevant book sections were included for review, and no minimum date parameter was set for the search.

2.4.3 Selection and Evaluation

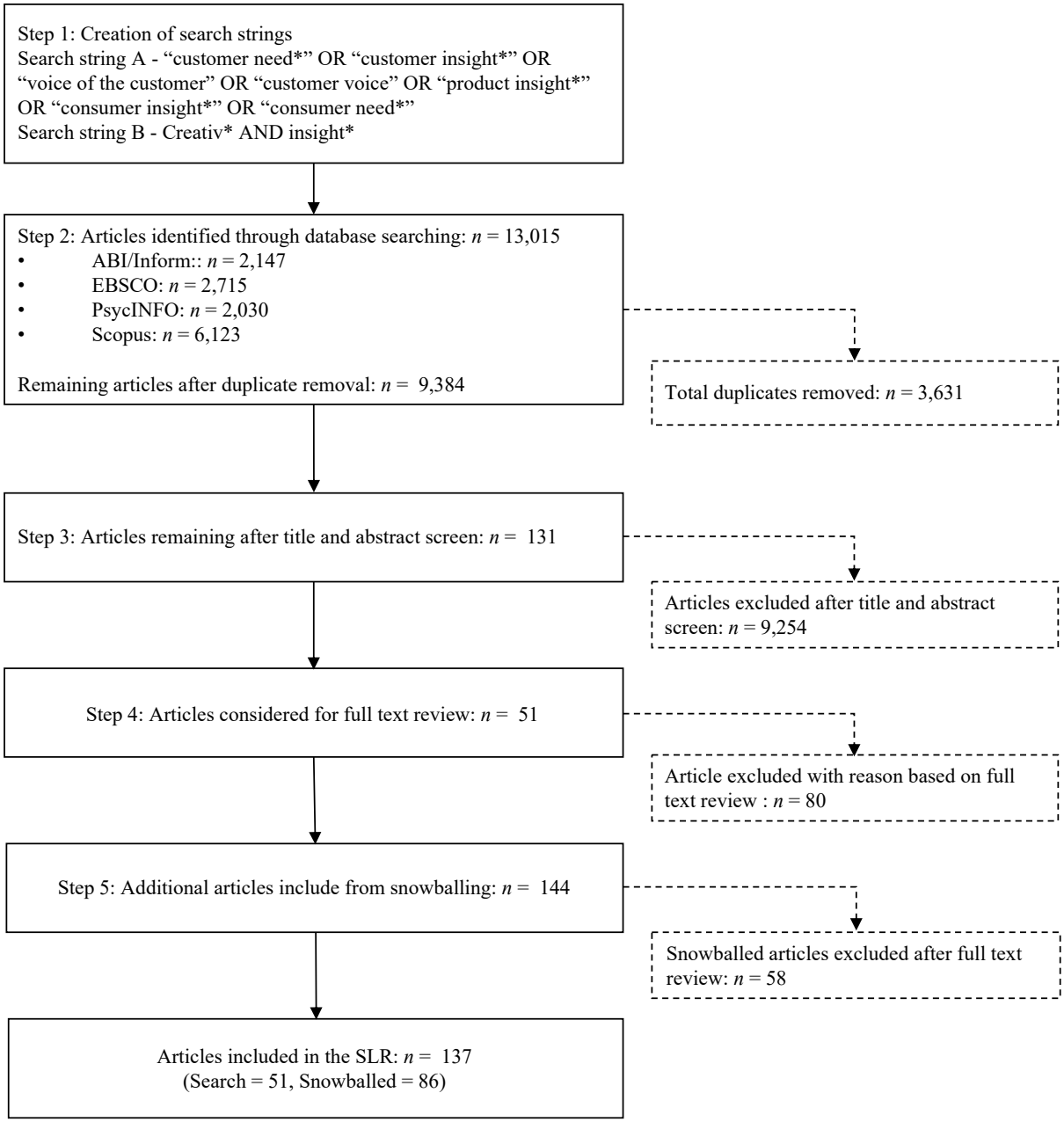
The 9,384 papers were spread across 3,670 distinct journals. However, the first review of the journal title led to excluding publications not relevant to the study; 5,120 articles were excluded using the journal title (representing 2,703 journals). For example, these journals were in fields not covered by this review, such as counselling, behavioural, developmental, education, tourism, politics, economics, finance, and foreign language. This exclusion measure resulted in 4,264 publications remaining for the next step. On the one hand, these journals could have been excluded at the search stage; however, only after the search was run and the results were reviewed it was established that these were not relevant. On the other hand, the search did not want to be too restrictive (e.g., only management journals), as this may have excluded relevant papers from other adjacent fields, such as psychology.

The next stage was to screen the publications on the publication's title and abstract using the inclusion and exclusion criteria given in Appendix A.1. This process resulted in a remaining total of 131 publications. This significant drop in publications was due to the use of the broad terms - 'insight' and 'need', which consequently captured articles

that were unconnected to this research. A complete text analysis resulted in a retention of a total of 51 and the exclusion of 80 publications. 144 additional publications were included in the review using snowballing, both forward and backward citation searching; of these, 86 publications were retained after a full-text review.

In summary, 51 articles were found using the SLR search process, and 86 were from snowballing. This SLR used 137 journal articles and books. 137 papers fall within Rojon, Okupe and McDowall (2021) range of 45 (25th percentile) to 148 (75th percentile) in their review of systematic reviews in management research. As such, it can be concluded that following the search and application the inclusion and exclusion criteria this SLR is based on are 137 articles and books.

Figure 2-7: Summary Flow of Publication Selection Process



Source: Author

2.4.3.1 Updated Systematic Literature Review Results

The last SLR was conducted in 2018, it was decided to update SLR to cover the years from 2019-2023. The updated SLR followed the same methodology as stated in Section 2.4. The same search strings (Section 2.4.2) were used in the four electronic databases. EBSCO, ABI/Proquest, PsycINFO and Scopus.

The search found a total of 10,140 publications for the period 2019 to 2023; search string 1 returned 4,303; Search string 2 returned 4,054. After removing duplicates using the Microsoft Excel function, the total was 6,900 unique articles. The same inclusion and exclusion criteria (Section 2.4.1 and Appendix A.1) were used; this excluded the majority of articles (514 remained). The search strings were broad and found a high number of articles that were mostly unrelated to the research, as explained in Section 2.4.2. The remaining articles (41) were reviewed on their title and abstract, which resulted in 18 articles for a full text review. These articles are listed in Appendix A.7 and covers innovation, management, marketing, and creativity research fields. Refer to Appendix A.6 for a figure showing the literature selection process.

2.4.4 Data Extraction

The data extraction step involved reading the complete article and extracting the relevant data into a standard data extraction form. This was created in Microsoft Excel. The data captured for each publication was: author, title, year, publication/journal, publication type, domain, RQ(s) or stated purpose of the article, focus area, article type, method (quantitative, qualitative, mixed), research method, data collection, data analysis, context (industry, country), main findings. Extracting and organising the data assists with synthesis and conclusions. This process tries to "build higher order theoretical constructs and create tentative theories of phenomena" (Rojon, Okupe and McDowall, 2021, p. 197) The data extraction table contained papers from areas that discussed the innovation, NPD, front end, insights, customer needs, creativity, design theories and market research. These areas assisted in answering the SLR questions. The data extraction table is shown in Appendix A.2.

2.4.5 Descriptive Analysis

2.4.5.1 Publication Type and Journals

The 137 articles covered 58 journals and 15 books. In considering the nature of the review, the journals covered fields across management, NPD and innovation, design, marketing, creativity, and psychology. The *Journal of Product Innovation Management* published the most publications, 26 out of the 137. Then followed *Research Technology*

Management with 10, *Harvard Business Review* with seven and *Creativity and Innovation Managemen*t with six. The data in Table 2-1 below shows significant interest from the NPD and Innovation field in understanding customer needs and insights. A complete list of publications across the 137 articles can be found in Appendix A.2.

Table 2-1. Journals with Three or More Publications in the Review

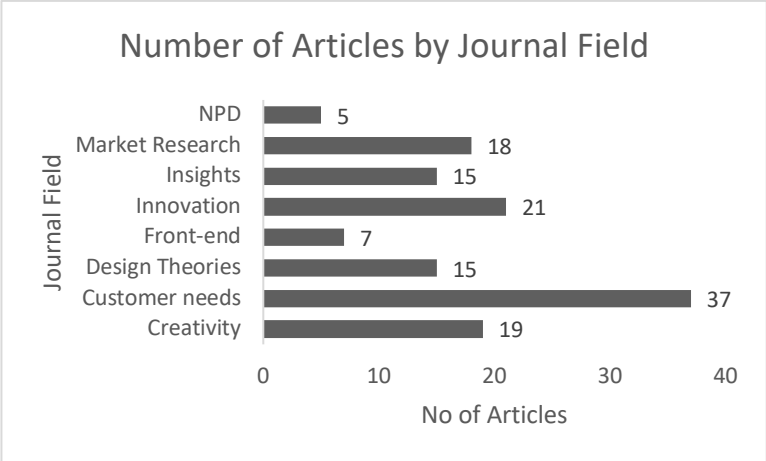
Journal Title	**No. of Publications**
Journal of Product Innovation Management	26
Research Technology Management	10
Harvard Business Review	7
Creativity and Innovation Management	6
Journal of Advertising Research	3
Creativity Research Journal	3
Journal of the Academy of Marketing Science	3
Management Science	3

Source: Author

Analysing the journal field, 41 publications came from innovation, 37 from management and 27 from marketing. The remaining are 12 for creativity, eight for psychology, six for production/quality and finally six from design theories. By analysing the journal fields, the data shows that 75% of the publications reflected the intersection of product innovation, management and marketing disciplines which are considered key areas to an understanding of customer needs and insights, see Figure 2-8.

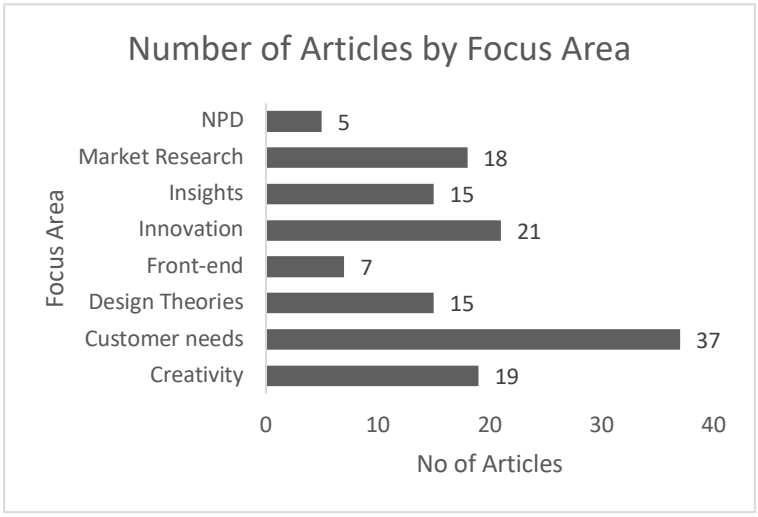
Analysing the publications' focus area, 37 publications discussed customer needs and 15 discussed insights, no publications address both needs and insights. Creativity (19) and innovation (21) were also two areas that appeared frequently, see Figure 2-9.

Figure 2-8: Number of Publications by Journal Field



Source: Author

Figure 2-9: Number of Publications by Focus Area



Source: Author

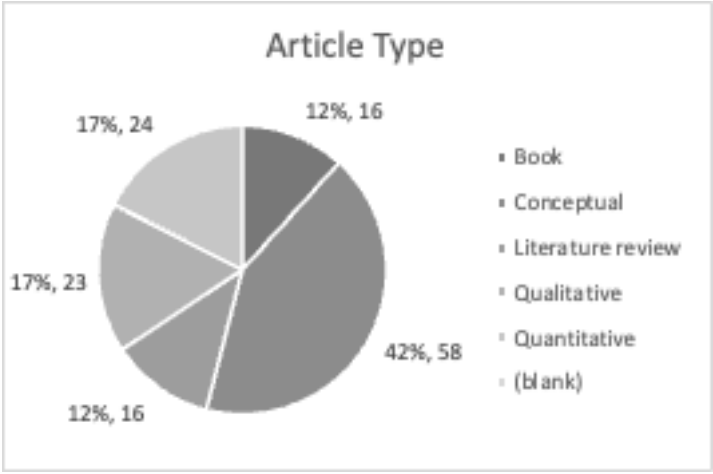
Figure 2-10 shows a histogram of the number of publications by year. Again, there is evidence that the number of publications has increased since 2004. Though this data reflected journals from diverse research fields, it suggested a growing interest in customer needs and insights.

Figure 2-10: Histogram of the Number of Publications by Year of Publication

2.4.5.2 Type of Research

The data also showed that the publication types are shared evenly across empirical and conceptual research; 47 empirical (quantitative 24, qualitative 23), 58 conceptual publications, 16 literature reviews and 16 books, see Figure 2-11.

Figure 2-11: Article Type



Source: Author

2.4.6 Empirical Studies for Customer Needs and Insight

There were 53 articles (37 needs, 15 insights) out of the 137 that specifically investigated customer needs and insights. Of these 53, 19 were empirical articles. Table 2-2 shows there have been 15 studies of customer needs, four of customer insights but no publications discussed the relationship between these two concepts. From a methodology perspective, the studies have either used a qualitative approach using case studies (4) or a quantitative approach (15) using surveys and questionnaires.

Customer needs have been investigated in NPD, with most studies finding that identifying customer needs drives new ideas, innovation, and business opportunities. For example, Bharadwaj, Nevin and Wallman (2012) found that hearing the customers' voice affects the creation and delivery of a superior value proposition. Another study by Griffin and Hauser (1993) showed that interviews with 20 to 30 customers uncovered 90% of customer needs. Furthermore, Narver, Slater and MacLachlan (2004) showed through the use of a questionnaire that market-oriented behaviours will lead to successful business opportunities. These studies used quantitative methods to understand the impact of identifying customer needs. Seven studies used interviews with managers to understand the perceptions of the value of customer needs. Another five studies used questionnaires to gain a larger sampling size than interviews. Karkkainen *et al.* (2001) investigated the

use of systematic methods in the assessment of new customer needs. Weigel and Goffin (2015) used a case study to investigate insight scouting teams and found that it takes time to build this type of capability. The study by Price, Wrigley and Straker (2015) showed that if teams dig deeper into the data to understand the why of customer behaviours, they can unearth new business opportunities. Table 2-2 summarizes the methodology used and key findings from the studies. The four insight studies used case study methodology. Price and Wrigley (2016) found that deep customer insights (DCIs) sparked inspiration for novel ideas and helped to build intimacy with customers. Said *et al.* (2015) conducted a case study in the UK and found that customer insight generation has multiple stages, for example strategy, conducting, processing, and presented a framework for insight generation. Following a case study conducted in Switzerland and Germany, Wieneke and Lehrer (2016) showed that mining social media data can generate insights into customer preferences and needs.

Analysing the empirical studies on their data collection method also showed that the majority (17 of 19) were retrospective, with only two being longitudinal studies (Weigel and Goffin, 2015; Price and Wrigley, 2016). This shows that most researchers have taken the stance that data collection regarding the customer needs and insights process can be approached retrospectively, and that bias or mis-recollection are not a concern. However, using only a retrospective approach to data collection could introduce bias with regarding to participants not recalling the events accurately. Also, the four insight articles were all in the marketing field, so there is opportunity to research insights in product innovation.

Table 2-2: Main Findings of 19 Empirical Studies

Publication	Focus Area	Research Method	Theoretical Perspective[1]	Main Findings	Comments
Baxter, Goffin and Szwejczewski (2014)	Customer needs	Retrospective Case study, Repertory Grid Technique	None stated	RGT provides deep insight into customer perception, offering an unbiased account of how customers view products. RGT can highlight key product attributes from a customer perspective, find the best-performing product, and identify unmet consumer needs.	Publication states that unarticulated needs are critical for success. But does not define needs or insights explicitly.
Bharadwaj, Nevin and Wallman (2012)	Customer needs	Retrospective Case study, Interview	Resource Based View on VOC	Hearing the VOC can affect the creation and delivery of superior value. Offers guidance to both sides of the buyer/seller dyad on how to manage supplier relationships. Buying firms should realise that they ought to opt for suppliers that are more customer-focused because those vendors are likely to outperform alternative providers along the lines of key performance metrics.	Publication is focused on the B2B relationship and confirmed that hearing the VOC can deliver a superior product value. No further definitions of needs and insights.
Bohlmann *et al.* (2013)	Customer needs	Retrospective Case study, Structured but open-ended interview	None specifically stated – Disruptive Innovation referred to	Customers have difficulty in identifying clearly what their needs will be even in the relatively near future. This difficulty in the projection of future needs can be understood as the lack of necessary hands-on experience of the benefits that new technological features introduce.	Presents a dynamic innovation framework to understand the customer of customer needs. Aer reports that minor changes to product helps in the customer journey and may increase potential benefits this is supportive of incremental innovation and customer needs.

[1] The theoretical perspective is important to understanding the study as it influences research design, research method and potential contributions.

Publication	Focus Area	Research Method	Theoretical Perspective[1]	Main Findings	Comments
Callahan and Lasry (2004)	Customer needs	Retrospective Questionnaire	None specifically stated – product newness referred to.	The importance of customer input increases with product newness to a certain level and then decreases for very new products and customer intensity of the market research methods used increases with the importance of customer input in new product development (NPD). The importance of the input of end-users and other customers is affected differently by product newness. In particular, the importance of end-user customer input decreases for very new products whereas the importance of other customer input does not.	Confirmed anticipating needs drive product improvements. Publication recognising that need evolve in dynamic products.
Cooper and Kleinschmidt (1987)	Customer needs	Retrospective Case Study, review of case histories and Interviews	None stated	Product advantage must be customer related, rather than solely technology based. This means that management must have a sound understanding of what the customer considers to be "a superior product." The implication is that a thorough investigation of customer needs, wants, and preferences should precede the product design and development stage.	Seminal paper on product success factors and recognising the importance of having customer needs defined early.
Cristiano, Liker and White (2000)	Customer needs	Retrospective Survey	None stated, QFD (quality functional deployment) as a management practice	The paper discussed the difference in QFD adoption in the US and Japan. US companies' emphasis on understanding new customer needs are likely to translate into a more significant impact on the final product and an increase in customer satisfaction. The results of the survey indicate that the US companies were more likely to collect new data on customer needs. Customer visits, individual interviews, focus group discussions were all important sources of customer information for the US QFD studies. In contrast, Japanese companies used existing, reactive product data sources significantly more than U.S. companies for their QFD studies.	Recognised that utilising market research methods to uncover needs can increase customer satisfaction, but paper did not discuss depth or quality of needs and there was no mention of insights.
Elfvengren et al. (2004)	Customer needs	Retrospective Case Study, Interview	None stated	GDSS offers significant benefits for the assessment of customer needs in industrial organisations. The features and benefits of GDSS can also facilitate the in-depth understanding of customers' needs. GDSS can have a significant time-savings in the customer need assessment process.	GDSS assists with structuring and facilitating the comprehensibility of large amounts of customer needs. Paper recognised that needs should be managed within the company by using an effective system.

Publication	Focus Area	Research Method	Theoretical Perspective[1]	Main Findings	Comments
Griffin and Hauser (1993)	Customer needs	Retrospective Interview	None stated	Interviews with 20-30 customers should identify 90% or more of the customer needs in a relatively homogeneous customer segment. Both one-on-one experiential interviews and focus groups seem to be effective at identifying needs, but the group synergies expected from focus groups do not seem to be present. Multiple analysts should analyse the transcripts. Regrettably, frequency of mention does not appear to be a good surrogate for importance.	This seminal paper first discussed VOC and defined needs. Process is still utilised today.
Karkkainen and Elfvengren (2002)	Customer needs	Retrospective Interview, Cognitive Mapping	None stated	The paper found that there is an unsystematic customer need assessment in all the studied companies. By understanding and communicating the customer needs a company can increase the number and extent of changes to product specifications, and thus decrease the effects of vicious loops in product innovation management (PIM). Problems related to the clarification of customer needs seemed to be a common and important early cause of the major managerial PIM problems in the studied companies.	An in-depth understanding of customer needs may be a quite effective means to decrease the number and extent of changes in product specifications. Highlights future needs are difficult to assess by multiple functions.
Karkkainen *et al*. (2001)	Customer needs	Retrospective Survey	None stated	The rate of regular use of systematic methods in the assessment of new customer needs was quite low, and almost 60% did not report utilising any methods in the assessment of new customer needs. Companies need to dedicate more resources and training to needs assessment.	Considered that clarification of hidden and future needs is important in customer needs assessment (CAN) process.
Lukas, Whitwell and Heide (2013)	Customer needs	Retrospective Questionnaire	Market Orientation	Customer orientation can play a key role in PIM by limiting a supplier firm's organisational culture to overshoot product capability. Efforts to build and leverage the virtues of adhocracy and market cultures must be accompanied by parallel endeavours to create restraints that align these cultures values with the needs of individual customers.	Shows that customers play a key role in an organisation for ensuring that the customer needs are not overshot by internal product requirements

Publication	Focus Area	Research Method	Theoretical Perspective[1]	Main Findings	Comments
Narver, Slater and MacLachlan (2004)	Customer needs	Retrospective Questionnaire	Market orientation	Market-oriented behaviours ultimately can and will be imitated successfully. Therefore, for any business to create and maintain sustainable competitive advantage continually, it must increase its proactive market orientation continually. The challenge for every business is to improve constantly its skill in learning more effectively and efficiently the specifics of, and superior solutions to, its target customers expressed and latent needs.	The paper reports that only focusing on expressed needs will not turn new insights into value adding opportunities.
Price, Wrigley and Straker (2015)	Customer needs	Retrospective Semi-structured interview	None Stated	Deep customer insight (DCI) methods can provide fresh, non-obvious ways of understanding customer needs, problems and behaviours that can become the foundation of new business opportunities. Findings concluded that DCI methods provide the critical layer to understand why customers do or do not engage with businesses.	The paper shows that combining traditional and new methods to uncover needs can lead a meaningful valuable insight.
Urban and Hauser (2004)	Customer needs	Simulation, Monte Carlo Analyses	None stated	Presents a methodology to listen in on customer dialogues with virtual advisers to identify combinations of customer needs that are not fulfilled. A proof-of-concept demonstration suggests that unmet needs combinations for real respondents can be identified.	By combining unmet needs new product ideas can be generated. Does not discuss insights.
Weigel and Goffin (2015)	Customer needs	Longitudinal Case study, Interview	None stated	Techniques are important but they must be supplemented by the right processes and, critically, by the right corporate culture. With these in place, organisations can use the insights harvested to develop radical products and significantly improve existing ones.	Paper states that it takes time and the right techniques to build a team to discover insights

Publication	Focus Area	Research Method	Theoretical Perspective[1]	Main Findings	Comments
Price and Wrigley (2016)	Insights	Longitudinal Survey	None stated	DCIs offer an analytical activity occurring within the abstract realm of thought where the problem was imagined and explored from multiple perspectives. Importantly, the deep customer insight approach builds intimacy with customers and stakeholders where small but powerful insights sparked inspiration for novel ideas. Design methods such as persona design, touchpoint timeline, and customer narratives provided suitable frameworks for making sense of the previously unknown customer.	The DCI Innovation Framework defines where design and gathering DCIs are applied within innovation process.
Said *et al.* (2015)	Insights	Retrospective Case study, Interviews	Market-based learning	Customer insight generation is comprised of multiple stages, from acquisition, to dissemination, application and storage of customer insight emerges from a process involving the collaboration of multiple individuals both within and across departments.	Insights once generated need to be translated and shepherded through the organisation. The paper recognises the importance of insights in the development process.
Thompson (1997)	Insights	Retrospective Case study, Interviews	None stated	Hermeneutic interpretations can highlight the symbolic meanings and patterns of personal concerns and life goals that constitute the unique frame of reference from which a person derives a coherent sense of personal history. Marketing gain insights that can enable them to develop products that are attuned to the meanings salient to the lives of consumers.	Using hermeneutics can provide deeper more relevant needs and insights
Wieneke and Lehrer (2016)	Insights	Retrospective Case study, semi-structured interview	Absorptive capacity	Firms can generate valuable insights about customer preferences and needs based on social media data. Beyond technology, human skills are required to interpret and understand the acquired data. Acting on customer insights allows firms to connect better with the marketplace by developing and commercialising new offerings faster and tailoring them to customer needs.	Paper recognises that both IT and people are required to uncover needs and insights

Source: Author

2.4.7 Methods Used in the Literature

The empirical studies utilised both quantitative and qualitative methods. Of the 137 articles, 24 used quantitative, and 23 used qualitative methods; the remaining studies were books, conceptual or literature reviews; refer to Figure 2-11: Article Type. Due to the nature of quantitative research, it is unsurprising that most studies undertook surveys/questionnaires to collect large data sets. Refer to Table 2-3 for a summary of the quantitative research methods.

Considering the qualitative methods in detail, all 22 qualitative articles used a case study, 16 used a multi-case study approach, and the remaining six used a single case study; refer to Table 2-4. Where these studies differed is in the tools used for data collection. Fourteen used interviews solely as a data collection method, whilst ten also used interviews but augmented their data by combining observation, survey data, or document review. Baxter, Goffin and Szwejczewski (2014) used the RGT for data collection. Consequently, interviews were the predominant tool used to collect data for case study research, with some studies enhancing the interview data with observational and historical data. The use of interviews in qualitative research, especially semi-structured interviews, has been reported to be the only "viable means to finding out" about participants' thoughts on a subject and provides a means to research retrospective events that observation alone cannot accomplish (Bryman and Bell, 2007, p. 506). Nevertheless, multiple data collection sources allow triangulation, enhancing the study's conclusions.

Reviewing the articles' data analysis methods, 15 used data coding or content analysis, and a subset of four used a grounded approach to analyse the data. Five articles used descriptive or hermeneutic data analyses, and two did not state their analytic tool. Data coding and content analysis tools are similar; they require *codes*, *categories,* and *themes.* A code is a word or short phrase that assigns a "summative, salient, essence-capturing, or evocative attribute for apportioning language or visual data" (Saldana, 2016, p. 4). A category synthesises codes, which is the consolidated meaning of codes. Finally, a theme (or concept) explains what the category means; it provides descriptive analyses and suggests a theoretical explanation for the phenomenon (Saldana, 2016).

The geographical location of the studies in the literature covered four different continents – North America, Europe, Asia, and Australia. Six studies located their cases in multiple countries and continents, typically the US, UK, Germany, and Japan. The selection of cases across geographical regions may increase robustness and generalisability by negating cultural differences and increasing the likelihood of the research being published.

The 22 qualitative papers were assessed for quality using the ten quality criteria laid out in the CASET (case study evaluation template) (Goffin *et al.*, 2019). CASET attempts to objectively evaluate case study articles against ten quality criteria. The assessment showed that the average CASET score was 5.9. There was a broad range of scores. Eight papers scored five and below, whereas six scored seven to nine. No paper scored a maximum of 10. However, one by Hargadon and Bechky (2006) scored nine; the authors did not state if they had conducted a pilot study. Most papers lost marks on three main criteria: a pilot study (all papers), review and validation (only one paper stated they had performed this step), and reflection on the validity and reliability of the study (only five papers stated this). The explanation of the data collection, multiple investigators, and case presentation and interpretation has been performed across the papers. This assessment has been crucial to inform the research

2.4.8 Summary of the Review of the Empirical Studies

It can be concluded from the literature that was identified and reviewed from the SLR that case study is the predominant methodology for enquiry and data coding for analyses in qualitative innovation management research. This analysis of the extant literature supports the choice of a case study as an appropriate approach to the investigation, as it has been used in many previous studies. For this PhD study to have a novel contribution, the interview methodology could be considered to build on previous studies. The extant literature showed that most empirical studies in the innovation management field involved multiple case studies. Considering the RQs, a multiple case study would also be appropriate here. A multi-case study allows the research to use a broader lens on the phenomenon of interest by looking across countries, organisations, and industries. The various data collection method will now be reviewed before an appropriate method is selected.

Table 2-3: Summary of Quantitative Research Methods

No.	Publication *Listed in chronological order*	Research Method	Data Collection	Data Analysis	Context (Industry, Country)
1	Cooper and Kleinschmidt (1987)	Survey	Survey, SAPPHO NewProd II	Likert 10 scale	US, Canada, UK
2	Griffin and Hauser (1993)	Survey	Survey	Statistical tools - Binominal analysis	US
3	Griffin and Page (1996)	Questionnaire/Survey	Survey	Statistical analysis	80 PDMA members
4	Cristiano, Liker and White (2000)	Questionnaire/Survey	Survey	Statistical analysis of mean responses	Japan and US SBUs
5	Karkkainen *et al.* (2001)	Questionnaire/Survey	Questionnaire, 5-point Likert scale	Statistical analysis	Finland, medium and large size companies
6	Koen *et al.* (2001)	Questionnaire/Survey	Survey, 7-point Likert Scale	Statistical analysis of mean responses	23 Companies
7	Danneels and Kleinschmidt (2001)	Survey	Survey, SAPPHO NewProd II	Statistical tools - factor analysis and multiple regression)	US, Canada
8	Gatignon *et al.* (2002)	Questionnaire/Survey	Survey	Factor Analysis	141 R&D Managers US, Scandia, France
9	Callahan and Lasry (2004)	Questionnaire/Survey	Questionnaire	Quadratic regression analysis	US, managers in 3 firms. computer telephony integration industry
10	Narver, Slater and MacLachlan (2004)	Questionnaire/Survey	Questionnaire	Statistical analysis	120 managers from 41 business units from 25 companies
11	Urban and Hauser (2004)	Simulation	Monte Carlo Analyses	Statistical analysis	US, car Industry

No.	Publication *Listed in chronological order*	Research Method	Data Collection	Data Analysis	Context (Industry, Country)
12	Kristensson, Gustafsson and Archer (2004)	Experiment	Quasi-experimental three-group (user type) design	Statistical analysis of mean responses	47 telecoms employees in Sweden
13	DeYoung, Flanders and Peterson (2008)	Insight problem test	Insight problem test	Statistical tools - descriptive, multivariant and regression analysis	108 University Students in Canada
14	Puccio and Grivas (2009)	Interviews	Four Sight measure	Statistical tools - descriptive, multivariant and regression analysis	137 University Students in US
15	Hillebrand, Nijholt and Nijssen (2011)	Questionnaire/Survey	Survey, 7-point Likert Scale	Statistical analysis	Dutch marketing and account managers of business-to-business firms
16	Bharadwaj, Nevin and Wallman (2012)	Survey	Survey	Factor Analysis	US, Procurement professionals
17	Kahn et al. (2012)	Questionnaire/Survey	Questionnaire	Statistical analysis	306 PDMA members in US, UK, Ireland
18	Lee and Therriault (2013)	Insight problem test	Cognitive tests	Statistical tools - descriptive, multivariant and regression analysis	206 US participants
21	Lukas, Whitwell and Heide (2013)	Questionnaire/Survey	Questionnaire, 5-point Likert Scale	Statistical analysis	317 Supplier and Customer in the IT industry in US
20	Creusen, Hultink and Eling (2013)	Questionnaire/Survey	Questionnaire	Statistical analysis of mean responses	Netherlands, Internet based, B-to-C Companies
21	Cunningham and MacGregor (2014)	Insight problem test	Insight problem test	Statistical tools - descriptive, multivariant and regression analysis	100 University Students in Australia

No.	Publication *Listed in chronological order*	Research Method	Data Collection	Data Analysis	Context (Industry, Country)
22	Frederiksen and Knudsen (2017)	Expert review	Student Workshop on idea creation	Statistical analysis of expert review	Denmark, assessment of novelty of product ideas

Source: Author

Table 2-4: Summary of Qualitative Research Methods

Number	Publication *Listed in chronological order*	Research Method	Data Collection	Data Analysis	Context (Industry, Country)	CASET Evaluation
1	Wallendorf and Arnould (1991)	Multi-Case study	Interview, Observation, Survey	Content analysis	US	6
2	Arnould and Wallendorf (1994)	Single-Case study	Interview, Observation	Content analysis	US, 1 family	6
3	Amabile (1997)	Multi-Case study	Interview	Data Coding	2 US Electronics companies	5
4	Khurana and Rosenthal (1997)	Multi-Case study	Interview	Content analysis	UE, Euro, Japan, 75 managers at 11 companies	6
5	Thompson (1997)	Single-Case study	Interview	Hermeneutics	Consumer perceptions in FMCG	7
6	Khurana and Rosenthal (1998)	Multi-Case study	Interview	Content analysis	US, Japan, Europe - 90 managers, 12 companies	5
7	Durgee, O'Connor and Veryzer (1998)	Multi-Case study	Interview	Content analysis	7 companies in various industries. Country not stated	3
8	Hargadon and Bechky (2006)	Multi-Case study	Interviews, project post-mortems, observations, tracking of projects, and documents and technological artefacts.	Data Coding, grounded theory	US, observation, 6 organisations	9
9	Arnould and Price (2006)	Single-Case study	Interview, Observation	Content analysis	US, 1 family	4
10	Rosenthal and Capper (2006)	Multi-Case study	Description of 2 product developments	Descriptive	US, 2 firms	6

Number	Publication *Listed in chronological order*	Research Method	Data Collection	Data Analysis	Context (Industry, Country)	CASET Evaluation
11	Griffin *et al.* (2009)	Multi-Case study	Interview	Data Coding, grounded theory	US, 11 Innovators	6
12	Jang *et al.* (2009)	Single-Case study	Interview	Content analysis	Phone company, Korea	4
13	Goffin *et al.* (2012)	Multi-Case study	NA	NA	UK, Germany, and Sweden. Service sector	5
14	Bohlmann *et al.* (2013)	Multi-Case study	Interview	Content analysis	US, 17 managers	7
15	Baxter, Goffin and Szwejczewski (2014)	Multi-Case study	Repertory Grid Technique	Repertory Grid Technique	2 in Germany; 1 UK 3 companies	5
16	Price, Wrigley and Straker (2015)	Multi-Case study	Semi-structured interview	Data Coding, grounded theory	Australia and multi-national - 13 firms	6
17	Weigel and Goffin (2015)	Single-Case study	Interview	Descriptive	Mölnlycke, medical devices	6
18	Said *et al.* (2015)	Multi-Case study	Interview	Data Coding, grounded theory	UK, 4 organisations	8
19	Carlgren, Rauth and Elmquist (2016)	Multi-Case study	Semi-structured interview	Data Coding	36 interviews with 4 companies. US, Germany	8
20	Frishammar *et al.* (2016)	Multi-Case study	Interviews, observations, workshops, and documented material	Data Coding	10 companies, 26 interviews	8
21	Price and Wrigley (2016)	Single-Case study	Review of technique for collecting insights	Descriptive	China - airport customers	5

Number	Publication *Listed in chronological order*	Research Method	Data Collection	Data Analysis	Context (Industry, Country)	CASET Evaluation
22	Wieneke and Lehrer (2016)	Multi-Case study	Semi-structured interview	Data Coding	Switzerland and Germany	6
					Average CASET score	5.95

Source: Author

2.5 CUSTOMER NEEDS

Uncovering customer needs from market research requires understanding the methods used to collect the market research data and then the analyses of the data (Callahan and Lasry, 2004). Needs can range from clearly expressed wants for product improvements to needs that the customer may not even be aware of (Goffin and Lemke, 2004). Although market research yields a wealth of valuable information, innovation teams are tasked with the challenge of transforming unstructured information into structured and easily communicable customer needs. Additionally, it is crucial for them to disseminate their knowledge in order to foster a broader comprehension of the problem at hand and generate potential ideas.. (Deichmann, Moser and van den Ende, 2020). This paper will examine the various definitions of customer needs found within the academic literature, as well as the methods utilized to extract and analyse this information.

2.5.1 Definitions of Customer Needs

The SLR found only eight publications provided definitions of customer need; these eight definitions will be reviewed below in chronological order of publication.

Holt, Geschka and Peterlongo (1984, p. 8) defined a need as "a lack of something that is wanted"; they described this as having two dimensions: 1) *existing* and *future* and 2) *emotional* and *rational*. Existing needs are explicit and can be easily articulated by the customer, who is consciously aware of these. Future needs arise through changes in society, the economy, or new technology; customers cannot easily predict and express these needs. By only addressing the current needs and not the future needs, the product may become irrelevant at the time of launch to the market (Karkkainen *et al.*, 2001). This is because the period between engaging customers in the FEI and launching a product may be significant (Agarwal *et al.*, 2014). As a result, a team has to try to envision the future and develop a product that will meet the future needs (Karkkainen and Elfvengren, 2002). Emotional needs are further broken down into three values, *attentive, symbolic* and *character*. Attentive values represent how the customer will be emotionally engaged, symbolic values refer to how the product affects the customer's self-image and status, and character values refer to how the customer reacts to the product's aesthetics. Finally,

rational needs meet the customer's functional and user requirements of the product; in other words, does the product fundamentally do the job? For example, can a toaster toast four slices of bread in under four minutes? Holt, Geschka and Peterlongo (1984) recommended that innovation teams separate the data into four classifications (existing, future, emotional, and rational).

The Kano Model, also known as the theory of attractive quality, conceptualised customer needs by breaking them down into three types: *must-be, performance* and *delighter* (Kano, 1984; Matzler and Hinterhuber, 1998). Must-be needs are the fundamental attributes that are taken for granted by the customer. The product must embody these needs; not having these needs catered for will lead to an unsuccessful product. Performance needs can be measured on a scale, such as cheaper, faster, stronger, and lighter. By improving on the performance needs, the product can be shown to be relatively better than the competition, for instance, a car's MPG rating or the loudness of a speaker measured in decibels. Finally, delighters are unexpected by the customer, and are the differentiators. However, the must-be needs are rarely articulated, as it is assumed that these needs will be present. Delighters, on the other hand, are not expressed because, at the time of asking, the customer does not know what they will want in the future or what will be technologically possible (Rejeb, Boly and Morel-Guimaraes, 2011). Consequently, the customer may only articulate the performance needs, expressed as an adjective with a trajectory – lower, smaller, faster, stronger, etc. Nevertheless, Kano and Holt's et al. concept of needs has a degree of agreement, as shown Table 2-5.

Table 2-5: Relationship between the Holt et al. and Kano Models of Needs

Holt, Geschka and Peterlongo, 1984	**Kano, 1984**	**Comment**
Existing	Must-Be	Both existing and must-be represent the same need classification. They are expressions of a known articulate need
Rational	Performance	As rational are functional/use needs, this aligns well with performance needs, as a function and use can be measured.
Future	Delighters	Both these needs are an unexpected need and cannot be articulated.
Emotional value - Emotionally attentive - Emotionally symbolic	N/A	The three Holt emotional needs cannot be directly related to the Kano Model; however, it could be considered that emotional needs fall into any of the three Kano needs.

Source: Author

Table 2-6: Summary of Customer Needs Terms and Definitions

No.	Reference	Field	Needs term	Customer Need Definition	Key descriptors
1	Holt, Geschka and Peterlongo (1984)	Management	Existing Needs	*"Explicit and can be easily articulated, the customer is consciously aware of these. Recognised discrepancy between existing and wanted situation"*	Explicit, Articulated
			Future Needs	*"Do not exist at present but will materialize in the future. May come from the availability of new technologies, adjacent technologies, or possible cultural and environmental changes"*	Future
			Emotion Needs	*"Emotional needs are broken down into three values. Attentive values represent how the customer will be emotionally engaged by using the product, symbolic values refer to how the product affects the customer's self-image and status, the character value refers how the customer reacts to the product's aesthetics"*	Emotion, values, character
			Rational Needs	*"Needs that meet the customer's functional and use requirements of the product – does the product fundamentally do the job it was purchased to do"*	Job
2	Kano (1984)	Innovation	Must-Be	*"Fundamental attributes that are taken for granted by the customer"*	Fundamental
			Performance	*"Existing needs that can be measured."*	Measured
			Delights	*"Unexpected by the customer"*	Unexpected
3	Hauser and Clausing (1988)	Management	Customer attributes	*"Phrases in the customer's own words used to describe product and product characteristics"*	Own words
4	Griffin and Hauser (1993)	Marketing	Voice of the customer	*"A description, in the customer's own words, of the benefit to be fulfilled by the product or service. Customer need is not a solution. Needs include basic needs, articulated needs, and exciting needs"*	Own words, benefit
5	Goffin and Lemke (2004)	Management	Hidden needs	*"Requirements that customers or users have but which they have not yet directly recognised. As these requirements rest on a sub-conscious level, users are unable to articulate them"*	Not recognised, unarticulated
6	Matthing, Sanden and Edvardsson (2004)	Marketing	Latent needs	*"What customers really value or the products and services they need but have never experienced or would never think to request"*	Value, never experienced

No.	Reference	Field	Needs term	Customer Need Definition	Key descriptors
7	Rosenthal and Capper (2006)	Innovation	Tacit Needs	*"Need that goes beyond the view of a product as a set of explicit performance features and functions and to consider the implications of the physical and emotional context of product use"*	Physical, emotional
8	Bohlmann et al. (2013)	Innovation	Dynamic customer needs	*"Customers evaluate the want and benefits of a new product from the reference point of their experience with similar products. Their needs will change as time progresses, due to their expectations of the new product."*	Benefits, change in time
9	Ulwick and Bettencourt (2008)	Management	Customer Need Statement	*"Reflect the customer's definition of value.* *Have universal acceptance.* *Be relevant now and in the future.* *Prompt a course of action.* *The statement's meaning must not be open to interpretation.* *The statement itself must not confound the way it or other statements are prioritized."*	Value, future, actionable

Source: Author

Expanding on the relationship of the three needs described by Kano, it has been shown that when a new delighter emerges, and it is then embodied into a new product, this delighter then starts to decline into a performance need and, finally, a must-be need (Witell, Löfgren and Dahlgaard, 2013). For example, the TV remote was a delighter in 1983; subsequently, by 1989, it entered the performance need category, where it increased in its functionality, and by 1998 it was a must-be feature for all TVs (Witell, Löfgren and Dahlgaard, 2013). Conversely, it has also been proposed that performance characteristics can return to a delighter need when performance characteristics exceed the user's expectations (Rust and Oliver, 2000). For example, mobile phone batteries typically lasted a few days between charges before the introduction of the smartphone. Today, however, a smartphone battery charge lasts at most a single day, clearly a decline in a performance need. Furthermore, it may result in users carrying an additional battery to top up the phone on the go. If a new battery technology could increase the available charge for a smartphone to exceed the current expectations, this could again become a delighter. It should be noted that if a team were innovating on the dimension of battery performance, the smartphone may never have been developed, as this performance need could never have met the existing battery technology (Veryzer and De Mozota, 2005; Christensen, 2011). When uncovering needs, the team must be clear on what they are addressing so that the team can innovate the product in the right direction.

In 1998, the term *customer attribute* was introduced into product innovation (Hauser and Clausing, 1988); these are statements in the customer's words used to describe a product or a product's characteristics. Griffin and Hauser (1993) refined the customer attribute term into a *customer need*, defined as "problems that a product or service solves and the functions it performs; they describe what products let you do, not how you do it". The authors also defined VOC as a "description, in the customer's own words, of the benefit to be fulfilled by the product or service", and the statement should not contain a solution and not be technology based. (Griffin and Hauser, 1993, p. 4). VOC remains popular today and is taught as part of the design for six sigma programs (Cristiano, Liker and White, 2000; Bharadwaj, Nevin and Wallman, 2012). An important point to note is that the VOC definition of a need conflicts with the Kano model delighter definition. If customers cannot adequately articulate their needs, then by using the VOC approach it would not be possible to uncover the unarticulated needs. VOC does not

clearly state if a need statement should either be verbatim, in the customer's own words or should have a level of interpretation applied by the innovation team.

There was criticism of the VOC approach; researchers realised that using the directly articulated VOC statements gathered through interviews, surveys, and questionnaires could lead to the development of incremental products (Bower and Christensen, 1995; Goffin *et al.*, 2012). The situation would effectively be innovating only Kano's performance needs because customers speak in the language that they are familiar with; referencing today's solutions and features, customers become fixated on how products are presently used and the issues they currently have (Patnaik and Becker, 1999; Hentschel, 2009; Goffin, Lemke and Koners, 2010; Goffin *et al.*, 2012). Therefore, if VOC statements are used, the innovation team should dig deeper by asking 'why?' to uncover the unarticulated customer needs. Subsequently, it has been proposed to address this criticism of doing what the customer states, by moving away from the VOC approach towards other methods for uncovering the unarticulated customer needs (Ulwick, 2003). The Kano model is still currently used, two authors in recent year have reported on its use in VOC and prioritising customer needs (Jach *et al.*, 2021; Haber and Fargnoli, 2019)

Authors have defined unarticulated needs to address customers' inability to articulate their needs (Ulwick, 2003; Baxter, Goffin and Szwejczewski, 2014), introducing concepts such as *hidden needs* (Karkkainen and Elfvengren, 2002; Goffin and Lemke, 2004), *latent needs* (Matthing, Sanden and Edvardsson, 2004; Carlgren, 2013) and *tacit needs* (Rosenthal and Capper, 2006). Hidden needs are defined as the "requirements that customers or users have but which they have not yet directly recognised, and these requirements rest at a sub-conscious level; users are unable to articulate them" (Goffin and Lemke, 2004, p. 3). Latent needs are "what customers value or the products and services they need but have never experienced or would never think to request" (Matthing, Sanden and Edvardsson, 2004; Jang *et al.*, 2009). Tacit needs are described as being subtle, and they are more than the function and performance characteristics of the product, they "consider the implications of the physical and emotional context of product use" (Rosenthal and Capper, 2006, p. 213). Identifying hidden, latent or tacit needs is crucial because competitors find it difficult to copy these needs and it provides a level of market differentiation (Narver, Slater and MacLachlan, 2004).

Bohlmann *et al.* (2013) introduced *dynamic customer needs*; they asserted that customers evaluate the benefits of a new product from the reference point of their experience with similar products. Dynamic customer needs change as time progresses due to their future expectations of new products and the increased experience of other products on the market. Therefore, the team must understand where the new product will be positioned in the overall market to understand a customer's future needs. As the term suggests, dynamic customer needs change with influences from the environment, market, and technology. Pursuing radical innovations increases the difficulty of predicting dynamic customer needs; the more innovative the product technologies are, the more the "ability to elicit customer needs and preferences decreases" (Bohlmann *et al.*, 2013, p. 239).

It has also been recognised that the definitions of customer needs did not address a need statement's structure, content, and format. Therefore Ulwick and Bettencourt (2008) proposed six characteristics of a customer need statement:

1. Reflects the customer's definition of value.
2. Has universal acceptance and relevance to all customers, no matter gender, geography, or income.
3. Be relevant now and in the future.
4. Prompts a course of action.
5. The statement's meaning must not be open to interpretation.
6. The statement itself must not confound the way it or other statements are prioritised.

Ulwick and Bettencourt (2008) further explained that six consistent rules should be followed when documenting a customer need: 1) the unit of analysis should be the jobs to be done, 2) the statement should not contain a technology, solution or product, 3) the statement should be unambiguous, 4) the statement should be brief, 5) the statement should be consistent, and 6) the statement should have consistency in structure, content, format, grammar and syntax. These six characteristics and six rules are the only criteria for writing a customer need found in the literature.

Having initially been articulated by Holt, Geschka and Peterlongo (1984) in the early eighties, the definition of customer needs has evolved and been refined by subsequent authors. Griffin and Hauser (1993) defined a general concept covering all needs. Others attempted to explain sub-concepts of needs, such as future, emotional, unarticulated, and dynamic. The nine customer need terms and their associated definition can be found Table 2-6 . The above section also described how a customer need statement should be written and what information it should contain. The following section will propose a harmonised definition of a customer need.

2.5.2 Proposed Definition of Customer Need

Essentially, a need reflects what the customer wants from the product but does not define how the product fulfils the want. As stated, the articulated needs (existing, must-be) are essential in developing a new product, as new products must embody these needs. Therefore, a new proposed integrated definition of a customer need must combine the research on articulate and unarticulated needs.

In the review the key descriptor words utilised in the various customer needs definition (refer to Table 2-6), i.e., 'value', 'benefit' and 'future' are stated the most frequently. 'Not solution based' is also mentioned, as the customer need statement should not suggest a solution or technology. Phrases regarding 'unable to articulate' (e.g., would never think of, not recognise) have also been used. These unarticulated needs are those that a customer cannot articulate because they are either future-orientated or based on changes in technology, society, or culture. Consequently, it appears that a definition of a customer need is centred around value and benefit. In reviewing the various customer need definitions in the extant literature, a revised customer need definition has been composed:

> *"A statement crafted by the innovation team that interprets the market research data and defines the customer's future benefit from and value of a product's use".*

Breaking down this conceptual definition into its parts:

1. *'A statement crafted by the team'* – The innovation team analyse the market research data and interpret (*craft*) this into a sentence/commentary that captures what the customer wants.
2. *'Reflects the customer's future'* – though the customer need is interpreted by the team (*reflect*), the customer still owns the customer need. As such, the need can change if the market or environment changes for/by the customer (*future*).
3. 'Benefit from and value of a product's use'– what will the customer gain (*value and benefit*), and the job they can perform better (*product's use)*.

Furthermore, in the Oxford English Dictionary (2017) the keywords are defined as:

a. *Statement* – a definite or clear expression of something.

b. *Craft* – an activity involving skill in making things.

c. *Reflect* – embody or represent faithfully or appropriately.

d. *Future* – A period following the moment of speaking or writing.

e. *Value* – worth or usefulness of something.

f. *Benefit* – advantage or profit gained from something.

2.6 CUSTOMER INSIGHTS

The term insight is mentioned frequently in the product innovation literature, but it is rarely stated what it means and is often used interchangeably with customer needs (Carlgren, 2013; Baxter, Goffin and Szwejczewski, 2014). The fields of psychology and marketing have both attempted to define an insight. Psychology has used the term insight to describe the culmination of the creative process (Simonton, 2001). Kounios and Beeman (2014) referred to insight as a sudden conscious change in a person's representation of a problem, characterised as breaking an impasse or mental block. Early in the twentieth century, Gestalt psychologists described an insight as a process based on reconstructing the core of a problem, rethinking its basic assumptions and originating a new and creative solution, a process usually occurring unexpectedly and unpredictably (Simonton, 2001). Kounios and Beeman (2014, p. 74) defined insight as a "sudden comprehension, realisation, or problem solution that involves a reorganisation of the elements of a person's mental representation of a stimulus, situation, or event to yield a non-obvious or non-dominant interpretation". Though an insight comes suddenly, considerable unconscious processing is involved before the insight. From a psychology view, insights are the outcome of restructuring the data or problem to yield a creative solution; they are processed unconsciously and arrive consciously as a sudden awareness.

Marketing has also attempted to define customer insight. Zaltman (2014, p. 343) described an insight "as a realisation, an idea that feels correct; it is a thought experienced as true at the moment it reaches awareness". Adding that insight is not an interpretation of a fact, "a fact announces 'I am', an insight answers the question 'so what'". Laughlin (2014, p. 76) offered this definition "a non-obvious understanding of your customers which, if acted upon, has the potential to change their behaviour for mutual benefit"; the author further defined the terms used in the definition:

- Non-obvious - does not usually come from a single source of information.
- Actionable - hypotheses that stay theoretical and cannot be tested in practice are not insights.
- Powerful - when they are acted upon, they can change behaviour.
- Sustainable - mutually beneficial to the customer and company.

Other authors have moved away from psychology-related definitions. For example, Florin *et al.* (2007) defined customer insight as an attempt to explain the why, when, and how customers purchase and use the product. In addition, Hillebrand, Nijholt and Nijssen (2011, p. 595) linked an insight to customer needs and defined it as an "understanding of current customer needs, the reasons behind these needs, and how these change over time". Wieneke and Lehrer (2016, p. 246) defined customer insight as "in-depth and actionable knowledge of customer needs and underlying motivations". However, these definitions suffer from being focused on marketing to the current customer. This may be due to the requirement to make fast changes to existing offerings compared to the long-run future that product innovation must consider.

Relating customer insight to knowledge, Wills (2005, p. 304) stated that insight is "a deep, embedded knowledge about the customers and the market around us that helps structure thinking and sound decision making". This definition is similar to the customer need definitions. It also includes a structural thinking and decision-making aspect, which gets at the causal understanding, and is not merely describing the customer's attitudes. Wills (2005) also offered two forms of customer insight - plural insights and singular insights. Insights are the multiple small discoveries that have definite applications in products and services. In comparison, insight is a broad knowledge that directs strategic thinking and decision-making, the strategic asset.

Smith, Wilson and Clark (2006, p. 136) defined customer insight as "knowledge about customers which meets the criteria of an organisational strength; that is, it is valuable, rare, difficult to imitate and which the organisation is aligned to make use of". Said *et al.* (2015) stated that information transformation is required to generate customer insight, as customer insight is not just information about the customer. Said discussed how insights are 'shepherded' around an organisation, but he did not offer guidance on how customer information is transformed into customer insights. Finally, Hamilton (2016) differentiated between consumers, who are general to an industry, and a customer, who has a specific relationship with a company, and concluded that consumer insights should be broad and not specific to a company's customers.

Both marketing and psychology have attempted to define the term insight; 12 definitions of insight were found in the literature. Refer to Table 2-7 which provides a list

of authors and definitions. The psychology definitions are from the cognitive/problem-solving aspect, whereas marketing is from the customer/market aspect. There was no customer insight definition found in the product innovation literature. If, as suggested, the discovery of customer insights leads to radical innovation, the SLR found no articles that attempt to define what a customer insight is in product innovation, which may suggest that the marketing definition of customer insights to used instead. However, this may not be appropriate for use in the FEI.

It can be seen from the key descriptors column in Table 2-7 that the definitions in the two fields do overlap, particularly with knowledge, understanding and comprehension. The previous section presented the definition of insight from both the psychology and marketing research perspectives. The following section will summarise the definitions and conclude with a proposed definition of customer insight in product innovation.

Table 2-7: Insight Definitions

No.	Reference	Field	Insight Definition (constructs within the quote are underlined)	Key descriptors
1	Oxford English Dictionary (2017)	NA	*"The capacity to gain an accurate and deep understanding of something"*	Accurate, deep understanding
2	Kounios and Beeman (2014)	Psychology Creativity	*"A sudden comprehension, realization, or problem solution that involves a reorganization of the elements of a person's mental representation of a stimulus, situation, or event to yield a non-obvious or non-dominant interpretation"*	Sudden comprehension, non-obvious, non-dominant interpretation Reorganisation
4	Simonton (2001)	Psychology Creativity	*"A process based on reconstructing the core of a problem, rethinking its basic assumptions, and originating a new and creative solution, a process usually occurring in an unexpected and unpredictable manner"*	Restructuring, rethinking, originating, creative solution
5	Zaltman (2014)	Marketing	*"A realization, an idea that feels correct; it is a thought experienced as true at the moment it reaches awareness. Not an interpretation of a fact, "a fact announces, 'I am' an insight answers the question 'so what'"*	Realization, feels correct, true, awareness
6	Laughlin (2014)	Marketing	*"A non-obvious understanding of your customers which, if acted upon, has the potential to change their behaviour for mutual benefit"*	Non-obvious, acted upon, benefit
7	Florin *et al.* (2007)	Marketing	*"Explains the why, when, and how customers purchase and use the product"*	Why, when, and how
8	Hillebrand, Nijholt and Nijssen (2011)	Marketing	*"An understanding of current customer needs, the reasons behind these needs, and how these change over time"*	Reason behind needs
9	Wieneke and Lehrer (2016)	Marketing	*"An in-depth and actionable knowledge of customer needs and underlying motivations"*	Actionable knowledge
10	Wills (2005)	Marketing	*"A deep, embedded knowledge about the customers and the market around us that helps structure thinking and sound decision making"*	Deep, embedded knowledge, structured thinking, decision making

No.	Reference	Field	Insight Definition **(constructs within the quote are underlined)**	Key descriptors
11	Smith, Wilson and Clark (2006)	Marketing	*"Knowledge about customers which meets the criteria of an organisational strength; that is, it is valuable, rare, difficult to imitate and which the organisation is aligned to make use of"*	Knowledge, valuable, rare, difficult to imitate aligned
12	Said *et al.* (2015)	Marketing	*"Not just customer information, to generate a customer insight from and about a customer requires transformation"*	Not just customer information, generate, transformation

Source: Author

2.6.1 Proposed Definition of a Customer Insight

As expected, the psychology definitions focus on the cognitive aspects of insight as a sudden realisation of the solution to a problem; insight from this perspective is the outcome of creative activity. This mental process aspect does not form part of the marketing definitions. Instead, they see an insight as deep new knowledge of a group of customers. The marketing literature also stresses the importance of insight being actionable within the organisation, which is different from a need – a need expresses value and benefit, not the action to meet the customer values and benefits. Therefore, customer insight can be seen as a deep understanding of customers' issues and problems.

It can be considered that a customer need is from the customer's perspective and that customer insight is from the innovation team's perspective. When the team analyse the market research data, they also discover the unique customer insights by restructuring the information. In this context, customer insight proposes a meaningful creative solution. A new customer insight that integrates the definitions found in the literature can be composed:

> *"A customer insight is an expression of deep knowledge about customers that leads to an actionable and non-obvious solution".*

Breaking down this conceptual definition into its parts:

- *'Expression of deep knowledge'* – The innovation team gain a unique interpretation and comprehension of the customer needs and market research data.
- *'Actionable'* – is practical and implementable.
- *'Non-obvious'* – restructuring the problem and recombining data to create unexpected ideas.
- *'Solution'* - means of solving a problem.

Furthermore, in the *Oxford English Dictionary (2017)* the keywords are defined as*:*

- *Expression* – the action of making known one's thoughts.
- *Actionable* – able to be done or acted on, having practical value.

- *Non-obvious* – not easily perceived or understood, not self-evident.
- *Creative* – the use of the imagination or original ideas.

The following sections will discuss how needs are uncovered, how insights are discovered and the relationship between customer needs and insights needs.

2.7 UNCOVERING CUSTOMER NEEDS

In this section the market research methods will be discussed. The papers from this part of the review reported on the techniques, methods and tools that are employed by companies and teams to uncover customer needs.

2.7.1.1 Collecting Market Research Data

Gathering market research data is an initial step in the process of uncovering customer needs. Both qualitative and quantitative market research methods are used by innovation teams, including focus groups, questionnaires, surveys, interviews (Zaltman and Coulter, 1995; van Kleef, van Trijp and Luning, 2005; Hamilton, 2016), ethnography (Arnould and Wallendorf, 1994; Mariampolski, 1999; Arnould and Price, 2006; Rosenthal and Capper, 2006), storytelling (Thompson, 1997; Price, Wrigley and Straker, 2015) and repertory grid technique (RGT) (Baxter, Goffin and Szwejczewski, 2014). These methods, familiar to social science have been applied in product innovation. The authors have reported on the advantages and disadvantages of each for uncovering customer needs, refer to Table 2-8.

Traditional enquiry methods, such as focus groups, surveys, and questionnaires, rely on asking the customer to reply to specific direct questions, requiring the customer to depend on their memory to recall specific situations and experiences (Durgee, O'Connor and Veryzer, 1998; Rosenthal and Capper, 2006; Schirr, 2012). The quantitative data typically produced is often abstracted into graphs and charts, which provide a general understanding of customers but may cause a loss of contextual detail about customer stories, concerns or issues (Gorry and Westbrook, 2011). These methods seek answers to the how, what, and where questions on product usage (Price, Wrigley and Straker, 2015). Baxter, Goffin and Szwejczewski (2014) reported that these

traditional methods only identify superficial customer needs, leading to incremental innovation.

Newer methods, such as *lead-user, co-creation, ethnography, contextual interviews*, and *repertory grid technique*, are more flexible in how they engage customers and have been shown to elicit hidden customer needs (Goffin *et al.*, 2012; van Kleef, van Trijp and Luning, 2005). These methods place the customer and interviewer within the context of product use, typically the environment where the product is used and is, therefore, a lived situation (Mariampolski, 1999).

Approaches, such as *lead-users* and *co-creation* (von Hippel, 1989; Prahalad and Ramaswamy, 2002; Thomke and von Hippel, 2012) proposed involving customers directly as active members of the innovation team who have direct input into product ideas, features, or concepts. Lead users are those users who have perceived and can articulate their future needs. By engaging these users, a team can develop products to meet the lead-user needs and, eventually, meet the broader future market needs (von Hippel, 1986). Co-creation involves the engagement of customers actively when ideas are created, and the product is developed. Their input guides the team in design decisions to direct the development (Ciccantelli and Magidson, 1993; Kristensson, Gustafsson and Archer, 2004; Thomke and von Hippel, 2012). Lead-user and co-creation methods recommend increasing user involvement in the product innovation process for long periods, increasing the likelihood that hidden customer needs will be uncovered. Frank *et al.* (2020) suggested 15 heuristics that can assist innovation teams when engaging in customer co-creation, to produce newer ideas that have a greater potential to achieve customer satisfaction.

Of the various methods mentioned, ethnography has shown the most benefit for uncovering unarticulated customer needs (Goffin *et al.*, 2012). In the product innovation context, ethnography is also known as consumer ethnography (Arnould and Wallendorf, 1994; Mariampolski, 1999; Arnould and Price, 2006; Rosenthal and Capper, 2006). Consumer ethnography aims to discover the underlying feelings and intentions of people who use a product and not just to understand the job being performed (Mariampolski, 1999). In studying product use, ethnography captures the "physical and situational surroundings, language, character, culture, and history" which may uncover deeper

meaning (Wallendorf and Arnould, 1991; Beckman and Barry, 2007, p. 31). Therefore, consumer ethnography studies the customer in their natural setting and "delves into the actual occasions and situations in which products are used and the benefits conferred" (Mariampolski, 1999, p. 75). It actively captures the who, doing what, with what, why they are doing it, the challenges, and the mitigations.

The process of consumer ethnography can be broken down into two distinct stages; participant observation and contextual interview (Rosenthal and Capper, 2006). Participant observation involves the researcher observing the customer performing the job of interest to capture the specific behaviours (Goffin *et al.*, 2012). For instance, a medical device designer may watch a surgeon performing surgery, or a household appliance innovation team may observe a customer cleaning their house. In addition to actively observing, these sessions are usually video recorded so that further analysis can occur after the event. By observing how the product is used and where the product is used, the researcher can overcome the “limitations of asking” (Mariampolski, 1999, p. 82). Consumer ethnography is especially useful when a job has multiple complex steps or is highly technical, as the transitions from each sub-task may be opportunities for innovation (Bettencourt and Ulwick, 2004).

A contextual interview is conducted after the observation; the interview is semi-structured and guided by the observational data (Goffin *et al.*, 2012). Though the ethnographer has a general guideline of topics and questions to cover, the interview is conversational. It can move fluidly to explore relevant issues uncovered during observation (Rosenthal and Capper, 2006). The conversation style of the interview has an advantage in radical innovation, as little is known about the customer needs, so the researcher may not know which questions to ask prior to the interview (Mariampolski, 1999). In addition, probing deeper to understand why the actions are performed may assist in finding the underlying cultural meanings and emotions (Wallendorf and Arnould, 1991; Thompson, 1997; Beckman and Barry, 2007). An advantage of the consumer-ethnography approach is the ability to compare what the team observed the customer doing with the customer's verbal responses.

Bettencourt and Ulwick (2004) proposed the 'customer-centred innovation map' to augment the consumer-ethnography method. This tool aims to divide the job to be done

into discrete tasks. Their premise is that customers hire products to get a job done. A job is defined as the activity undertaken by the user to solve a problem, and the use environment is the context of the job, e.g., to hang a picture, the user could use a solution such as a hammer and a nail to accomplish this task. However, the picture hook may need to be placed into a brick wall, and a hammer and nail may work only on plasterboard, so the user may have to use either a drill, rawl plug and screw solution or an adhesive hook to accomplish the job (Ulwick, 2002). By mapping the job from the customer's perspective, areas for innovation can be found by looking at what factors constrain or prohibit the customer from getting their job done effectively. Once created, the map can be analysed to find opportunities for improvements for each task's inputs and outputs by combining, moving, reordering, or removing steps. Finally, by understanding what the customer experiences for each job when using a product, the team can develop newer products that better meet the customer's needs.

Although these methods have their benefits and limitations, authors have recognised that "traditional methods are useful, but they need to be combined with techniques to identify hidden needs" (Goffin and Mitchell, 2005, p. 155). By using multiple methods to collect data from different viewpoints, innovation teams can mitigate the limitations and enhance their ability to uncover hidden needs.

In recent years, mobile phones have become an invaluable tool for collecting customer feedback. Mobile market research applications (MMRAs) are now being utilized as a new Voice of Customer (VoC) tool. As Green, Cluley and Gasparin (2019, p. 53) noted, this method is not only cost-effective and efficient but also allows for the gathering of large datasets more quickly than traditional methods. However, incorporating these newer tools requires innovation teams to invest time and money that could otherwise be allocated to more common methods of customer engagement (Verganti, Vendraminelli and Iansiti, 2020). Additionally, customer needs are diversifying at an unprecedented rate due to newer technologies that provide customers with access to more information. This has led to mass personalization, accompanied by new customizable manufacturing techniques such as 3D printing (Ozdemir, Verlinden and Cascini, 2022). By integrating these tools with AI (discussed in Section 2.9), the future of customer insights and research will be highly dynamic.

Table 2-8: Market Research Methods Advantages and Disadvantages

Traditional Methods	**Key References**	**Advantages**	**Disadvantges**
Interviews	Hamilton (2016)	One-to-one interaction Deeper understanding	Cost and time Difficult to analyse across interviewees
Focus Groups	Schirr (2012)	Group interaction Consensus building Low cost and time	Members may feel inhibited Groupthink Facilitation
Questionnaire/Survey	Durgee, O'Connor and Veryzer (1998)	Large population	Response Rate
Newer Methods	**Key References**	**Advantages**	**Disadvantages**
Ethnography	Arnould and Price (2006); Arnould and Wallendorf (1994); Beckman and Barry (2007); Bettencourt and Ulwick (2004); Goffin *et al.* (2012); Mariampolski (1999); Rosenthal and Capper (2006); Wallendorf and Arnould (1991)	Deep understanding	Observer influence Time-consuming Sampling error, small participant group
Repertory Grid Technique	Baxter, Goffin and Szwejczewski (2014); Goffin and Mitchell (2005)	Deep understanding	Obtaining adequate amount of elements Artificial nature has influence Cost and time
Co-creation, Lead-User	Ciccantelli and Magidson (1993); Kristensson, Gustafsson and Archer (2004); Prahalad and Ramaswamy (2002); Thomke and von Hippel (2012); von Hippel (1986); von Hippel (1989)	Key users with deeper knowledge of the product's use	Small group of users Complexity in engaging them
Storytelling	Gorry and Westbrook (2011); Price, Wrigley and Straker (2015)	Deep understanding	Small group of users Complexity in engaging them
Interviewing-ZMET	Zaltman and Coulter (1995)	Deep understanding	Small group of users Complexity in engaging them

Source: Author

2.7.2 Market Research Data Analysis

To analyse the market research, it has been proposed that innovation teams are required to look for key indicators to find inconsistencies in customer words and actions, such as *workarounds* and *affordances* (Gibson, 1986; Norman, 2013). A workaround is when users overcome a limitation with an existing product to accomplish the job (Patnaik and Becker, 1999; Goffin *et al.*, 2012). An affordance is the product's properties. Affordances are signs that indicate how the product is used and show the possible user interactions. A design affords a surface, shape and texture (Norman, 2013), e.g. a hammer affords a shaft with a rubberised, oval-shaped, coarsely textured handle that signals to the user to grasp the product correctly.

Furthermore, the team are required to find triggers and cues, such as looking for *over generalisations, metaphorical glosses, claims of idiosyncrasy,* and areas of *disjuncture* in doing and saying (Arnould and Wallendorf, 1994; Goffin *et al.*, 2012). An overgeneralisation is an "absolute descriptor". It is a statement from the user that may contain 'I always…', 'I never...', etc. A metaphorical gloss captures the meaning of the activity to the user, not the actual task being done by the user. A claim of idiosyncrasy is the user stating unique experiences that differ from other users. Finally, a disjuncture is a variation between the user's responses to interview questions, and the user's observed action (Arnould and Wallendorf, 1994). Another cue can be found when an existing solution does not provide a perceived benefit and is expressed as confusion, resignation or contradictions as the customer tries to find a way to decrease the dissonance (Letelier, Spinosa and Calder, 2000). Finding these triggers is time-consuming but will aid in uncovering the hidden customer needs.

Empathic design proposed further types of cues that can be used (Leonard and Rayport, 1997). First, the *trigger of use* attempts to uncover why the customer is using a particular product; this may involve both conventional and unconventional use. Considering the context of product use, the interaction with the user's environment may highlight critical design issues regarding how the product is used with other products. Finally, user customisation may also show areas for innovation; the user could have made changes to the base product to overcome design problems.

When analysing the data to uncover customer needs, it is also essential to consider the upper and lower thresholds the product is required to perform. Simon (1996) in his influential book 'The Sciences of the Artificial', introduced the term *satisficing*, a portmanteau of satisfy and suffice. It suggests that customers will accept a good enough solution for their purposes and will not put any additional effort into finding the optimal solution that meets all their needs. Teams could fall into the trap of spending resources on developing a superior product when the customer may not require it and not even notice the additional features and functions. As a result, the team is overshooting the customer's needs (Lukas, Whitwell and Heide, 2013). Therefore, the team should consider what the customer sees as good enough product capabilities, or in other words the minimum viable product (MVP) (Ries, 2011). Engaging in market research data analysis and looking for triggers and cues will increase the ability of the team to uncover the deeper customer needs.

2.7.3 User-Engaged Innovation

In the past few decades, involving the user in the innovation process, particularly in the front end, has been crucial for successful innovation. Design theories have emerged as a means to better engage the user, understand their needs and uncover valuable customer insights.

The development of these design theories was an attempt to understand customer needs and insights by building processes around how market research should be conducted and analysed. Design theories are the principles of and research into design as an activity (Krippendorf, 2011). These theories have proposed changing the viewpoint of engaging the user from a marketing to a *design* approach (Liedtka, 2015). Design refers to developing an artefact that meets new needs (Simon, 1996). Ulrich (2011) mentions two historical definitions of design Kaufman, in 1946, described design as “conceiving and giving form to objects used in everyday life”, and Krippendorff, in 1984, referred to design as “the conscious creation of form to serve human needs”. Ulrich (2011) defined design as a “human problem-solving activity beginning with a perception of a gap in a user experience, leading and resulting in an artefact”. Thus, product design attempts to create solutions to solve human-centred problems (Veryzer and De Mozota, 2005) by combining both problem-solving methods and cross-functional teams (Beckman and

Barry, 2007). There are three significant design theories that have emerged: *empathic design* (Leonard and Rayport, 1997), *design thinking* (Buchanan, 1992; Brown, 2008), and *human-centred design* (IDEO, 2011; Veryzer and De Mozota, 2005). Although these theories have considerable crossover, they all attempt to understand people's underlying issues and produce solutions to meet wants and needs.

Empathic design stresses that the key to success is observing the customer using the product to accomplish the job - similarly to consumer ethnography. Authors have criticised the use of surveys, interviews and questionnaires, as the facilitator can introduce bias in the questions or draw biased conclusions from the answers (Leonard and Rayport, 1997) Furthermore, critical information may be missed "when a customer needs are solicited in writing or through constrained dialogue and pummelled with statistical logic" (Leonard and Rayport, 1997, p. 105). Empathic design proposed five phases: observing the customer in their environment, capturing the data through videos and photographs, and reflecting and analysing the captured data. In the fourth phase, the team brainstorm possible solutions based on the reflections and analysis. The final stage involves prototyping and evaluation by the customer (Leonard and Rayport, 1997). Empathic design acknowledges that following what the user requests does not lead to innovative ideas, but the user can be a guide to a deep, empathic understanding of user needs. In this approach, understanding customer needs occurs during the brainstorming and is refined through prototyping and evaluation.

Like empathic design, human-centred design (HCD) emphasised building a deep relationship with the people who use the product to truly understand their needs. The process consists of three phases. In the first inspiration phase, the team learn directly from the people using the product through observation. In the next step, ideation, the team make sense of the information by creating design concepts and then prototyping and testing these concepts. The final implementation phase involves the production and release of the final product to the customer (Brown and Katz, 2011; IDEO, 2011). A similar process called user-centred design (Veryzer and De Mozota, 2005; Norman and Verganti, 2012; Norman, 2013) tried to understand the context of use as the user interacts with a product to identify the whole user experience to improve the product's usability. Veryzer and De Mozota (2005) describe HCD as an outside-in method where the users are involved in the design decisions and where technology innovation is secondary. HCD

has come under increased criticism; Norman and Verganti (2012) have realised that asking users about products and observing them using existing products has led to incremental innovation. Observing existing products will improve the user experience of existing products but will not necessarily lead to radical innovation.

Design thinking dates back to a book by Rowe in 1987 (Dorst, 2011) and a paper by Buchanan (1992) on 'Wicked Problems in Design Thinking', in which Buchanan stated that systematic thinking is required for the exploration of new ideas and that the design profession was ideally placed to tackle this problem. As such, the theory of design thinking has been shown to be grounded in creativity and cognitive theories (Auernhammer and Roth, 2021). Design thinking was further championed by Tim Brown and David Kelley at the IDEO design consultancy (Brown, 2008; Brown and Katz, 2011; Carlgren, Rauth and Elmquist, 2016). Proponents see the method as primarily a "problem-solving process and not just an innovation process" by bringing design principles, approaches, and methods to problem-solving (Liedtka, 2014). This elevated role of a designer and design thinking in solving customer problems has become a key element in product innovation (Carlgren, Rauth and Elmquist, 2016). Core to design thinking is the intersection between desirability, feasibility and viability (Price, Wrigley and Straker, 2015). Desirability is the customer needs, feasibility is the technical likelihood of the product concept being made, and viability is the commercial appeal. Design thinking has five phases: understand, observe, conceptualise, validate, and implement. Design thinking continuously focuses on the problem, empathising with the user's emotional and functional needs. For instance, the conceptualising stage, where ideas are prototyped, allows the team to experiment and test ideas with customers (Liedtka, 2015).

Design thinking has undergone an evolution in recent years, transforming into design-led innovation management. By leveraging design tools, the goal is to instil a design culture that drives strategic conversations and actions (Frank *et al.*, 2020; Knight, Daymond and Paroutis, 2020). Randhawa *et al.* (2021) explored the implementation of design thinking at the organizational level. They used design thinking tools such as ethnography, interviews, and observation to uncover user and customer needs. The case study concluded that this is crucial for identifying innovative opportunities. However, the

article did not provide a definition of customer needs within the context of design thinking, nor did it discuss or mention the term "customer insight".

The design theories discussed share three phases. They all have an observation phase, a problem solution phase, and a prototype phase; refer to Table 2-9 for a cross reference of the stages of the design theories. Where they differ is when the design process begins and when it finishes. For example, design thinking does not mention customer needs as a concept and transitions from observation directly to brainstorming. Design thinking also introduces an understanding phase before the observation phase, which can be thought of as problem finding (Griffin *et al.*, 2009; Frishammar *et al.*, 2016). Furthermore, empathic design has two phases for observing and capturing data, whereas human-centred and design thinking combine these into a single observation phase. Additionally, both human-centred and design thinking include an implement phase at the end of the process, but empathic design finishes the process at the prototype phase.

Table 2-9: Comparison of Design Theory Approaches

<table>
<tr><th>Empathic design
(Leonard and Rayport, 1997)</th><th>Human-centred design
(Buchanan, 1992; Brown, 2008)</th><th>Design Thinking
(Veryzer and De Mozota, 2005)</th></tr>
<tr><td></td><td></td><td>Understand</td></tr>
<tr><td>Observing</td><td rowspan="2">Observing</td><td rowspan="2">Observe</td></tr>
<tr><td>Capturing data</td></tr>
<tr><td>Analysis</td><td rowspan="3">Ideation</td><td rowspan="2">Conceptualise</td></tr>
<tr><td>Brainstorm solutions</td></tr>
<tr><td>Prototyping</td><td>Validate</td></tr>
<tr><td></td><td>Implementation</td><td>Implement</td></tr>
</table>

Source: Author

In contrast to the design theory approaches, Verganti (2009) presented an inside-out starting point for addressing customer needs; he proposed the Design-Driven Innovation (DDI) model, whereby companies provide new meanings to customers. He suggested that “DDI does not start from customer insight”. Instead, it comes from offering “possible breakthrough meanings and product languages that could emerge” (Verganti, 2008, p. 438). DDI recognises that some successful teams did not engage customers, as their customers could not provide the required information. Instead, companies offer new products assuming customers would appreciate and buy them. Though the theories

recognise that design has moved on from styling and aesthetics and improved functionality and performance, Verganti (2008, p. 440) offered that to be radical, a product should appeal to the latent desires and "emotional and symbolic values" embodied in the term "product meaning". DDI proposes new sociocultural meanings to potential customers via a finished sellable product. Verganti concluded that if customers cannot identify with new meanings, why bother asking them.

Empathic design, human-centred design, and design thinking propose that observing customers is the primary method for collecting market research data. Furthermore, they do not suggest preparing any need statements. Instead, a problem-solution phase is undertaken using design practices, such as ideation, brainstorming, and prototyping, to satisfy customer needs, thus, jumping from understanding the problem to providing a solution. Moving directly to the prototype stage without an analysis phase could present a problem as this may already position the innovation team on a particular technology pathway. On the other hand, DDI suggests that the innovation team already understands the customer's wants and needs. Hence, it advocates not engaging customers but moving directly to the solution phase so that the idea can be tested. In contrasting these methods, they range from suggesting deep customer engagement to limited engagement. Where a team chooses to sit on the customer engagement/market research spectrum may depend on the type of product being designed and developed. This was a brief review of the design theories. A future study could try to map out the product innovation customer engagement spectrum with the market research techniques and methods, and with their associated advantages and disadvantages.

2.8 DISCOVERING CUSTOMER INSIGHTS

Authors have reported that the capability to discover customer insights is a creative *problem-solving* activity and that *creativity* is an antecedent of product innovation (Kristensson, Gustafsson and Archer, 2004; Arthur, 2007; Cunningham and MacGregor, 2014). Creativity is the ability to produce ideas that are both novel (original, unexpected) and useful (Amabile, 1988). Problem-solving refers to "a situation in which one's current state differs from some goal state, and in which there is some uncertainty as to whether or how the goal can be achieved" (DeYoung, Flanders and Peterson, 2008, p. 278).

Furthermore, problem-solving is proceeded by problem formation (Hargadon and Bechky, 2006), which depends on the individual's and team's experience and knowledge.

Problem-solving has been described as a sequence of events; the individual consciously tries various solutions, consistent failure occurs, and no other solutions can be thought of, so an impasse is reached. The unconscious mind then starts restructuring the problem over a period, then hopefully, a breakthrough - the aha moment occurs. A fully formed solution is presented in the conscious mind "the breakthrough results in a change in the way one deals with the world: the breakthrough has a transformative quality" (Weisberg, 2015, p. 21). The impasse stage is crucial after many incorrect solutions have been worked through consciously but failed to solve the problem. At this point, an alternative interpretation of the problem is activated, resulting in realising there is another way to solve the problem (Davidson, 1995). Through creative problem-solving, the innovation team increase their chances of discovering unique customer insights.

Creativity produces novel solutions to problems in the changing environment in which we live, and it is core to invention, innovation, and eventual NPD (Arthur, 2007; Cunningham and MacGregor, 2014; Wallas, 2014). Creativity has been defined as the "capacity to produce ideas that are both original and adaptive, and the ideas must be both new and workable or functional" (Simonton, 2011, p. 2). Wallas (2014) described creativity as having four essential stages: 1) Preparation, the problem is detected, and the relevant data are identified; 2) Incubation, the unconscious mind works on the problem; 3) Illumination, the idea is realised; the "aha" Moment; and 4) Verification, the idea is tested against acceptance criteria. Incubation and illumination are unconscious, whereas preparation and verification are conscious activities. A similar creative process specifically for product development has also been suggested: 1) problem identification and clarification, 2) idea generation, 3) idea evaluation and solution development, and 4) implementation (Puccio and Grivas, 2009; Harvey, 2014).

The creative process also involves using divergent and convergent thinking to solve problems and discover insights (Buijs, 2007; Cropley, 2006; Cropley and Cropley, 2012). Divergent thinking includes producing many ideas by creating combinations and associations in unexpected ways. There is no right or wrong answer in divergent thinking, and each creative individual may have a different novel interpretation (Simonton, 2001).

On the other hand, convergent thinking is focused on finding the single correct, unambiguous solution to a problem from the available information; it is effective when the answer already exists (Cropley, 2006). Both divergent and convergent thinking work together and are complementary during creativity (Lee and Therriault, 2013).

The creative and problem-solving processes described are very similar and overlap; both have been explained as linear processes. It is acknowledged that an individual regularly cycles back and forth between the stages when additional information is discovered, or new connections in the data are made. Therefore to be considered creative, an idea and eventual product have to be original, novel and provide a benefit to the user (Kristensson, Gustafsson and Archer, 2004)

Serendipity, a discovery of a solution by chance, is another area in creativity research. Along with many historical examples (Columbus, Davy, Nobel, Fleming, etc.), Simonton (1999) presented five types of serendipity: 1) an individual tries to solve a problem but fails, however over time, the solution finally presents itself; 2) an individual tries to solve a problem, but a fortuitous event occurs, luck plays a part in finding the solution; 3) an individual finds a solution to a problem they are researching, but also discovers a more profound understanding, a surprising finding; 4) an individual finds a solution to a different more profound problem during the process of finding a solution to the problem they are researching; 5) an individual is just generally exploring an area with no defined problem and discovers a solution to a problem. Types 1 and 2 are called pseudo-serendipity, as the person is actively investigating the specific problem and found a solution. These types are similar to the Guilford (1950) first two stages, discussed above, whereby the person will have previously prepared and incubated the problem. Types 3, 4 and 5 are recognised as true serendipity as these involve an unexpected discovery; these contradict the Guilford stages as there was no conscious preparation or incubation of the specific problem before illumination. These types circumvent the problem-solving and creative processes.

The role of the individual in creativity and discovering insights is essential (Guilford, 1950; Avital and van Osch, 2013). Amabile (1988) investigated individual creativity and reported three characteristics that are key to being creative: *domain-relevant skills, creativity-relevant skills,* and *intrinsic task motivation*. Domain-relevant

skills are the explicit and tacit knowledge, technical skills and talent possessed by the individual. Creativity-relevant skills are the cognitive abilities allowing for that "something extra" over and above the domain-relevant skills. The final element, intrinsic task motivation, is an individual's internal drive to start and finish a creative task. Extrinsic task motivation may help get the job started, but intrinsic task motivation will sustain the individual through long, difficult times. In addition, fluency (flexibility and synthesising ability) coupled with a *high capacity working memory* also contributes to creative ability. A high capacity working memory provides a rich source of readily accessible information that can be interpreted quickly to generate novel ideas (Griffin *et al.*, 2009; Lee and Therriault, 2013). Another aspect of working memory is combining domain-relevant skills and knowledge across multiple other domains to find even more novel combinations (Sprugnoli *et al.*, 2017).

The link between *invention* and creativity is fundamental, as innovative products have a higher return than standard products (Euchner and Henderson, 2012; Cunningham and MacGregor, 2014). Arthur (2007, p. 274) proposed that the process of invention is recursive problem-solving and has a logical structure, "at the heart of the invention is an act of individual insight in which the essential solution to the problem was arrived at". Arthur (2007) explained that invention has four steps: first is the perception of the problem or unfilled want. Second, is the setting of the stage whereby information is gathered on the situation. The third step is the act of insight, where the problem's solution is discovered. The final step is iterative, the insight is revised and improved to better meet the need. Product innovation aims to gain economic advantage and profit, so the invention must be refined and exploited economically (Cooper and Kleinschmidt, 1987; Reinertsen and Smith, 1997; Frederiksen and Knudsen, 2017).

Invention is driven by creativity, so for an idea to be considered creative, it must be novel, useful and have market potential. Combining problem-solving, creativity and invention coupled with the product innovation process are crucial business capabilities to gain a competitive advantage. Amabile (1997, p. 39) argues that creative ideas "can't be simply bizarre; it must be appropriate to the problem or opportunity presented", the idea must be commercially viable.

2.9 RELATIONSHIP BETWEEN CUSTOMER NEEDS AND INSIGHTS

So far, the literature review discussed the definitions of needs and insights and how they are uncovered and discovered. From the definitional perspective, it has been proposed that these two terms are separate concepts. Therefore, this suggests that there must be a relationship between the two. However, does understanding the relationship matter and warrant being studied? If, as proposed, customer needs lead to incremental innovation and customer insights lead to radical innovation, then understanding how they relate to each other is worthwhile. Because, firstly, for academics investigating what innovation teams are doing in the FEI, it will allow them to better comprehend the data from case studies research and secondly, for practitioners being able to categorise their findings from market research into needs and insights may assist in considering how they prioritise the type of innovation they are pursuing.

There appears to be a gap in the available literature that discusses the relationship. In the literature on needs and insights, a subset of seven papers discussed both needs and insights. See the summary in Table 2-10 of the seven papers that referred to the relationship. In the other papers in the literature review, product innovation only referred to needs and did not discuss customer insights. On the other hand, the marketing literature discussed insights and did not mention needs. Table 2-10 shows the difference in the statements in the seven papers that referred to a relationship between needs and insights. As can be seen, insights are referred to as a component of a need (four papers), a separate concept from a need (three), and as both a concept and component (one). From a process perspective, two papers suggested that insights come from a need.

Table 2-10: Customer Insight Relationship

Author	Statement from paper	Commentary	Main Idea
Baxter, Goffin and Szwejczewski (2014, p. 34)	"Achieving this level of insight is very difficult, in part because not all customer needs are equal. There are a number of customer insight methodologies that can enable firms to identify hidden needs."	Firstly, this paper referred to insight as a component of a need, possibly interpreting insight as a deeper level of understanding of need. It also uses the customer insight methodologies as a way of identifying needs. It is not clear on the difference between insights and needs.	Insight methods allow the discovery of insights that lead to needs.
Carlgren (2013, p. 1352)	"Operationalisation of insights once latent needs have been identified. To interpret these insights and transform them into something tangible and capable of being fed into the further development of features and concepts, a translation step is needed".	This paper suggested that insight follow needs and are the 'operationalisation' of a latent need. This operationalisation translation process is not well explained.	Needs lead to insight that led to features and concepts.
Hillebrand, Nijholt and Nijssen (2011, p. 595)	"Understanding of current customer needs, the reasons behind these needs, and how these change over time".	The paper referred to an insight as being reason for a need.	Insight is an understanding of the need.
Narver, Slater and MacLachlan (2004, p. 338)	"A proactive market orientation, focused as it is on latent needs, leads to even deeper insight into customer needs and, thus, to the development of innovative products and services".	This paper referred to an insight as being a deeper understanding of a latent needs, and not a separate concept. Insight is a component of a need, that explains that need.	Insight is an understanding of the need.
Price and Wrigley (2016, p. 1)	"Design-led innovation is an innovation process that begins with gathering deep customer. … Deep customer insight methods form part of a design-led approach offering an intimate shared understanding of the unspoken, latent current and future needs of the customer".	This paper referred to insight methods leading to a shared understanding of unspoken needs. The paper did not adequately explain an insight, only discussed the methods.	Insight as a concept and its associated method.

Author	Statement from paper	Commentary	Main Idea
Weigel and Goffin (2015, p. 3)	"Those who attended the analysis workshop were intrigued by the way customer insights emerged from finding and interpreting clues to customer needs".	This paper suggested that insights are a concept, and they emerge from needs.	Insight as a concept, that come from needs.
Wieneke and Lehrer (2016, p. 246)	"Firms that have the capability not only to acquire but also to make sense of social media data in their business context can turn this data into valuable customer insights, that is, in-depth and actionable knowledge of customer needs and underlying motivations. These insights can be exploited to create added value to customers by tailoring offerings to their needs".	This paper suggested that insights are a concept that has knowledge about needs. The second part confused the understanding that insights are also needs at a deeper level.	Insight from data, insights as a concept but also a component of a need.

Source: Author

The following section will attempt to further understand the relationship between insights and needs. Four possible interactions could be considered:

1. A need and insight are synonymous.
2. Need and insight are overlapping.
3. They are different concepts and have an antecedent; either an insight follows a need, and/or a need follows an insight.
4. They are different concepts and do not relate.

It can be seen in Table 2-11 that of the relationships there is no evidence for synonymous, overlapping, antecedent – insight to need or no relationship. There are three papers that refer to an insight following a need (i.e., need to insight).

Table 2-11: Relationship between Needs and Insights

Relationship	Summary of Evidence	Reference
Synonymous	No evidence was found in the literature.	NA
Overlapping	No evidence was found in the literature.	NA
Antecedent – need to insight	Insights are operationalised from the customer needs; translating insights from identified needs.	Carlgren (2013)
	Finding a right combination of unmet needs will produce a superior product, suggesting that an insight is a combination of needs.	Urban and Hauser (2004)
Antecedent – insight to need	No evidence was found in the literature.	NA
Do not relate	No evidence was found in the literature.	NA

Source: Author

In discussing latent needs, Carlgren (2013) suggested that insights are operationalised from the customer needs by using a creative translation step and proposed a framework: identifying current needs, corresponding to both must-be and attractive needs; anticipating future needs, taking into account the life-cycle of quality attributes; and translating insights from identified needs. However, this translation step in the framework was not expanded upon, so it was difficult to understand how insights come from needs. Urban and Hauser (2004) also suggested that finding the right combination of unmet needs will produce a superior product, implying that an insight is a combination of needs. In a paper presenting the RGT, the authors suggest that new product offerings

are "based on insights into customer needs to be gleaned from the RGT constructs" (Baxter, Goffin and Szwejczewski, 2014, p. 34).

It should also be recognised that a product can be developed with just an understanding of the customer's needs. This approach may lead to incremental innovation, innovating on the must-have and performance characteristics. As previously stated, in reviewing the definitions, it can be proposed that these are different concepts and, therefore, cannot be synonymous, so this precludes the first possibility. However, the literature does not clarify the relationship, and the lack of evidence does not propose a clear connection. Consequently, to fully understand how they relate, further investigation is needed.

2.10 DISCUSSION AND CONCLUSION

The review investigates into the crucial aspects of customer needs and insights within the front end of the product innovation process. The main objective is to define these concepts, understand their relationship, and explore the associated activities that facilitate the discovery of needs and insights. The research involved a thorough analysis of 137 articles in the field of needs and insights to develop our review and establish clear definitions. While the product innovation industry understands customer needs well, there are some contradictions regarding customer insights and the discovery process. This indicates that the process of uncovering customer needs and discovering customer insights is complex and poorly researched, presenting an opportunity for further investigation.

2.10.1 Discussion

Product innovation management is a vast area of research. The literature has indicated that many authors have proposed various front end frameworks (Reinertsen and Smith, 1997; Khurana and Rosenthal, 1998; Koen *et al.*, 2001; Cooper, Edgett and Kleinschmidt, 2002), each providing a more in-depth understanding of the process. In this area of study, the exploration of customer needs and insights is a crucial aspect of the front end innovation process.

The review of the literature has brought to light three essential findings. Firstly, it has been established that uncovering customer needs and discovering insights is a part of

the FEI. Secondly, empirical research indicates that there are two types of needs, articulated and unarticulated, and several methods have been researched to uncover both. Lastly, the relationship between needs and insights is not clearly defined; there are conflicting explanations. For instance, some consider insights to be a component of needs, while others see them as a separate concept. Additionally, only one author has examined the order of needs and insights., i.e. Carlgren (2013).

Through the process of conducting a comprehensive literature review, it has become evident that the definitions work in harmony with one another. Specifically, while the customer needs definition outlines the values and benefits that a given product provides to a customer, the insight definition offers a deeper understanding of the customers themselves. These two definitions give a more complete picture of the, which can then inform the development of products and services that better meet their needs and wants. Table 2-12 shows the two definitions side-by-side.

Table 2-12: Customer Need and Insight Definitions

Customer Need Definition (Section 2.5.2)	**Customer Insight Definition (Section 2.6.1)**
A statement crafted by the innovation. team that interprets the market research data and defines the customer's future benefit from and value of a product's use	A customer insight is an expression of deep knowledge about customers that leads to an actionable non-obvious solution

There are several market research methods, including interviews, focus groups, surveys ethnography, repertory grid, and co-creation. Once collected, the data requires analysing to uncover the needs; the review offers specific guidance on analysing market research data, focusing on observation and interview data. Additionally, we explore user engagement approaches such as human-centred design and design thinking. These have emerged as effective ways to engage customers and better understand their needs by designing processes around market research.

Insight discovery depends on a team's knowledge, experiences, and creativity. Teams with the ability to acquire and make sense of data within their business context can turn this data into valuable customer insights (Wieneke, & Lehrer, 2016, p.246). When innovation teams review the same market research data, they may uncover similar

customer needs but could discover different customer insights. This is because customer needs are inherent while the team discovers insights. Although the needs may be the same for all innovation projects, the insights may differ, leading to different product design outcomes. Additionally, each team can combine and interpret customer needs differently, leading to unique and non-obvious customer insights that can be taken forward into radical and innovative product solutions. Since a team consists of individuals with diverse experiences and motivations, the insights may differ from team to team. Similarly, teams within different companies with varying capabilities (creativity, problem-solving, inventiveness) may discover insights based on their unique abilities. For instance, a mechanical engineering team may discover very different insights from a software engineering team. Therefore, an insight is open to various meanings and interpretations. A "new order of structure emerges" once a new insight is discovered, leading to the realisation of a new product. (Bohm, 2004, p. 12).

According to the creativity literature, discovering an insight can be seen as both a problem-finding and problem-solving process. However, the marketing literature considers it a deeper understanding of a customer's need. It can be suggested that these different concepts of insight are situated at different stages of the FEI process. At the initial stages of FEI, the deeper understanding of the customer’s wants is considered a marketing insight. As the FEI progresses into finding solutions, the creativity definition of insight takes over.

The present study delves deeper into customer needs and insights. Firstly, it highlights how the discovery of insights leads to the identification of newer customer needs. Secondly, it emphasizes the importance of market research in uncovering customer insights and design prototyping in discovering design insights. While the product innovation literature has underscored the significance of market research in uncovering needs and insights, the design literature has shown that prototyping is equally crucial in discovering design insights. Furthermore, the creativity literature provides an understanding of the insight cognitive process. However, these research fields do not yet offer an integrated understanding of need and insight in FEI.

2.10.2 Conclusion

Ongoing research in the realm of customer needs and insight continues to be an active area. Various tools and techniques have been examined by scholars in the pursuit of uncovering customer needs. However, there remains a gap in comprehending the relationship between the literature on creativity, product innovation, and the discovery of customer insights. Product innovation exists at the intersection of both the marketing and creativity domains, and this may account for the confusion in both literature and practice. The current study seeks to bridge this gap by providing a deeper understanding of the insight discovery process. Consequently, further exploratory research is necessary to explain the connection between customer needs and insights, as well as how insights are discovered and where they fit within the FEI.

2.11 RESEARCH QUESTIONS

The SLR suggested new definitions for customer needs and customer insights and confirmed that they are distinct concepts, however this requires further empirical testing. There remain areas of interest for future research; the following two RQs, have been created to address these areas of interest:

RQ 1) How are customer needs related to customer insights in practice in the work of innovation teams at the front end of innovation?

As highlighted in the literature, there is limited research regarding the relationship between customer needs and customer insights and how these terms impact in the front end product innovation process, future research may assist in clarifying this relationship.

RQ 2) How does the process of discovering customer insights unfold within innovation teams?

The process of discovering insights could be explored using a case study, this research could produce a framework for the FEI. For instance, a case study could explore how a team uncovers needs and discovers insights, and this could explain a revised FEI process.

2.12 SUMMARY OF SYSTEMATIC LITERATURE REVIEW CHAPTER

This chapter provided a systematic review of the literature on customer needs and customer insights. It aimed to understand what customer needs and customer insights are, how they relate to each other in product innovation and what approaches to market research data for uncovering customer needs and discovering customer insights are used in the front end of product innovation. Using the SLR, definitions of a customer need and of a customer insight are developed from the literature. However, it remains unclear how the two concepts are related; though some publications suggested that the discovery of insights follows the uncovering of customer needs this was not fully substantiated. This phenomenon requires future exploratory research. Chapter 3 will build on the findings of the SLR and review the research design, this is then followed by Chapter 4 the proposed research method.

CHAPTER 3 RESEARCH DESIGN

3.1 INTRODUCTION

Chapter 3 considers the research design. Research design should be appropriate to the research questions being addressed (Yin, 2018) and has been defined as a statement and justification for the technical decisions involved in planning a research project (Blaikie, 2010). Research design establishes the research question (RQ), strategy, philosophical perspective, and method. Each component should be aligned for a successful research project (Creswell *et al.*, 2007; Blaikie, 2010).

This chapter has five sections. The first section states the RQs established from the SLR (Chapter 2). In the second section, the philosophical perspectives in innovation management research are considered, and the research is then located within a critical realist philosophy. The third section discusses the research method. In the fourth section, the data collection and data analysis approaches that have been used are discussed. The final section explores the theoretical lens and proposes the lens for the research.

Chapter 3 is organised into the following sections:

- Research question
- Consideration of the philosophical perspectives
- Research method
- Data collection approach
- Theoretical perspective

3.2 RESEARCH QUESTION

The SLR showed that uncovering customer needs and discovering customer insights in the context of product innovation is a complex and not well-researched topic. Studying the relationship between these two concepts is interesting as no previous research into this phenomenon appears in the literature. As the discovery of customer insight is a cognitive process, this cannot easily be observed; therefore, the appropriate research design must be selected. To close the research gap, the research attempted to understand

how customer insights in product innovation are discovered and provide a conceptual relationship between customer needs and insights. The SLR defined a customer need as a 'statement crafted by the team that reflects the customer's future benefit from and value of a product's use' and customer insight as 'an expression of deep knowledge about customers, that leads to an actionable non-obvious, creative solution'.

The two RQs resulted from the findings of the SLR and determined the scope and type of research design:

RQ 1) How are customer needs related to customer insights in the work of innovation teams at the front end of innovation?

RQ 2) How does the process of discovering customer insights unfold within innovation teams?

3.3 CONSIDERATION OF THE PHILOSOPHICAL PERSPECTIVES

Understanding the philosophical perspective enables the appropriate research design to be selected. The philosophical stance combines the perspective of the world and the phenomenon being studied (Blaikie, 2010). Knowledge about a phenomenon is framed by the researcher's *ontological* and *epistemological* view of the world. Therefore, the researcher must state their reality and belief in knowledge. Ontology combines the nature of being and the researcher's assumptions about reality. For instance, is there an objective reality, or is reality subjective?

Epistemology is the theory of knowledge and is concerned with "knowing how you can know" (Hatch and Cunliffe, 2006, p. 14). Therefore, first and foremost, the researcher must understand the various philosophical perspectives in management research to develop an effective research design. Thus, in the following section, three philosophical perspectives*, positivism, constructivism,* and *realism,* are discussed, and the adopted philosophical stance is justified. These three perspectives have been chosen as they exist on a philosophical spectrum. Figure 3-1: Research Design Flow illustrates how this sub-section is laid out with the considerations, conclusions, and linkages for each sub-section.

3.3.1 Discussion of Philosophical Perspectives

This section will discuss three philosophical perspectives in the research context: positivism, constructivism, and realism. The first philosophical perspective in the review is *positivism. T*his was discussed by philosophers such as Plato and Bacon. Positivism is grounded in the scientific method and is the basis of the Western philosophy of science (Kuhn, 2012). Positivism aims to investigate what is happening using scientific measurement (Partington, 2002). It posits that there is a single objective truth based on the cause and effect of a natural phenomenon. Positivism attempts to uncover causal relationships and explain the relationships between phenomena (Symon and Cassell, 2012). In organisational theory, positivists "assume that language mirrors reality, that is, reality and its objects can be described using language without loss of meaning or inherent bias" (Hatch and Cunliffe, 2006, p. 13). The positivist researcher is neutral in examining and collecting data through their sensory experience and measurement techniques. Objective results are interpreted systematically so that the data speaks for itself, which seeks to minimise any bias introduced by the researcher (Benton and Craib, 2010). Consequently, the positivist researcher strives for objectivity and the opportunity for bias that can influence the results and findings so that the research can be replicated by others (Blaikie, 2010). Furthermore, Carl Popper proposed a fundamental tenet of positivism known as the falsification principle, which states that results and findings are true until disproved (Denzin and Lincoln, 2011).

On the other end of the philosophical spectrum from positivism is *constructivism*. Constructivism postulates that there are multiple realities, and that the world is socially constructed (Denzin and Lincoln, 2011). Constructivists interpret facts that are dependent on the person who holds these realities. Consequently, these are personal realities of the world, not generalisable truths. Therefore, the researcher constructs knowledge of the world through lived experiences and their interaction within the society to which they belong (Benton and Craib, 2010). This philosophical approach typically collects qualitative data by collaborating with societal members through interviews and observations to discover the meanings behind what people think and do (Denzin and Lincoln, 2011). The results and findings from constructivist research are subjective as the researcher cannot separate themselves from their reality when interpreting the data.

However, constructivists recognise and strive to minimise bias by attempting to articulate these biases in the research findings.

The third philosophical stance to be considered is *realism*. Realism theorises that the nature of the world exists independently of the human social interpretation of the world (Bhaskar, 1978). However, realists concur with constructivism that knowledge is socially constructed and that human knowledge and understanding of the world can be researched. Realism sits somewhat between positivism and constructionism on the subjective/objective philosophical spectrum (Hatch and Cunliffe, 2006). Realists believe that reality cannot be observed directly but exists through human perspectives and experiences. Therefore, observing social interactions and interrelating with participants can uncover and explain a phenomenon. Critical Realism has been applied to many studies in the social sciences (Bhaskar, 1978) and innovation studies in particular. For example, Koners and Goffin (2005) researched post-project reviews. Critical Realism typically utilises qualitative research methods, as knowledge of reality is mediated by our perceptions and beliefs, which can be accessed through interviews and observations.

The three philosophical perspectives discussed are compared in Table 3-1: Philosophical Perspectives. The comparison begins with the ontological and epistemological views and concludes with a commentary on the implications of the current research. The philosophical perspectives discussed have outlined the various options in the innovation management field where a researcher can choose to investigate the RQs. The choice of philosophical perspective must match the phenomena being investigated, in consideration of the subjective-objective orientation of the researcher and regarding their worldview and the social context of both the researcher and the participants.

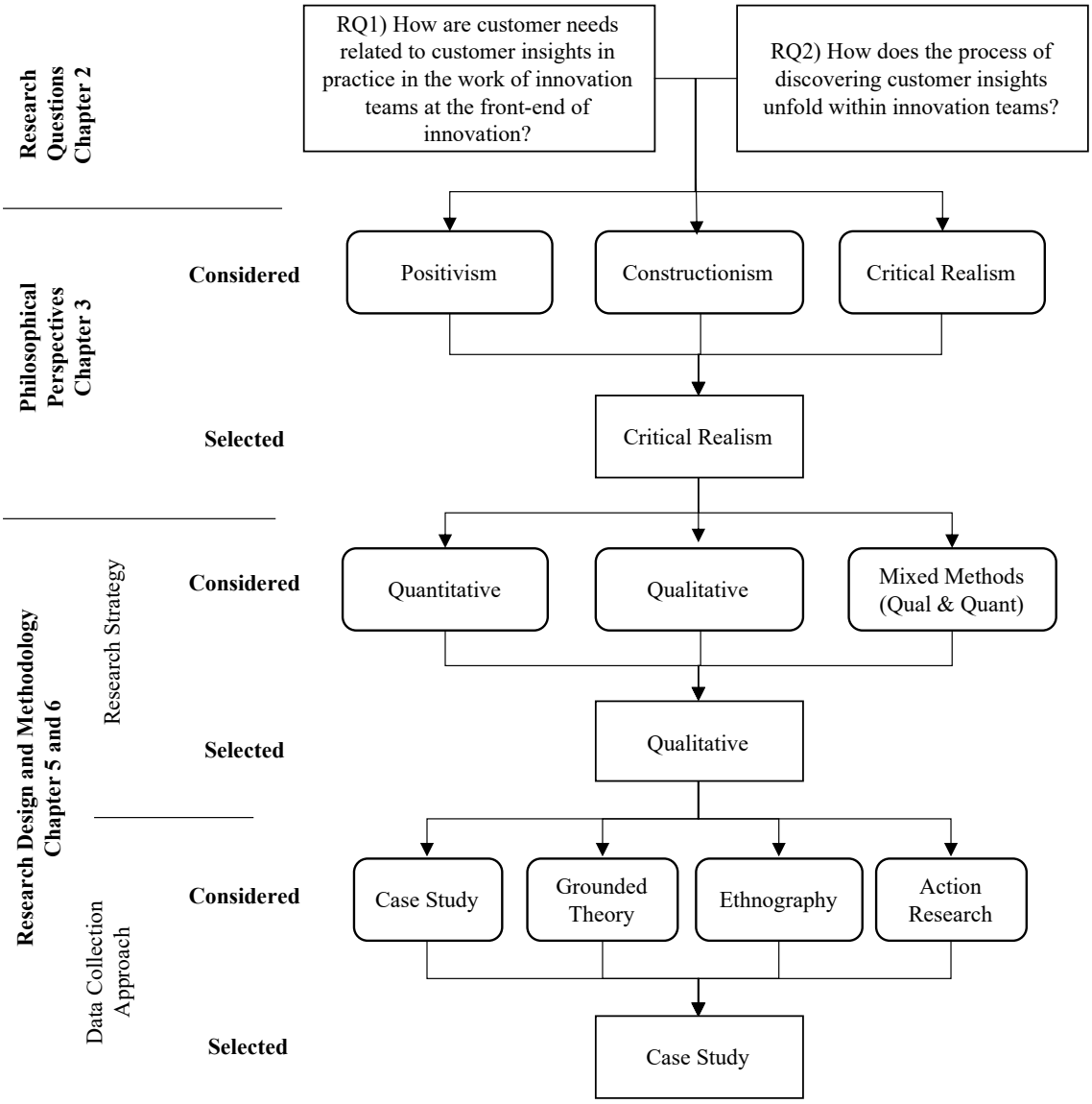
Table 3-1: Philosophical Perspectives

Philosophy	**Positivism**	**Constructivism**	**Critical Realism**
Ontology *World view and assumptions of researchers. What is the nature of reality?*	External, objective, and independent of social actors. Single identifiable reality.	Socially constructed, subjective, multiple, and changing.	Empirical - observable. Experiences and perceptions. Actual - observable events. Real - unobservable.

Philosophy	Positivism	Constructivism	Critical Realism
Epistemology *The process of thinking. What is the relationship between research and those being researched?*	Observable objective facts, universal causal laws, or generalisations.	Shaped by our lived experiences.	Observations and events. Underlying tentative generative mechanisms.
Methods Used	Scientific method. Hard sciences. Belief in the falsification principle, replication, hypothesis testing.	Hermeneutic, dialectic grounded theory, discourse analysis, action research.	Mainly qualitative – case, grounded theory, action research.
Aim	Prediction and control of natural phenomena.	Subjective meanings and interpretations around social phenomena.	Objective meanings and interpretations around social phenomena.
Nature of knowledge	Hypothesis is verified as fact.	Constructed meaning of actions.	Constructed meaning of actions.
Knowledge accumulation	Cause and effect.	Informed reconstructions.	Theory building and explanation.
Objective	Prediction.	Causal – interpretive through tentative underlying generative mechanisms. Shared knowledge between researcher and participant.	Description and social phenomena.
Data	Rigorous data, highly structured with large samples, primarily quantitative.	Small samples in-depth rich data, qualitative.	Mainly qualitative, small samples, some use of quantitative data and methods.
Commentary on implication for the current research	Customer insight discovery cannot be easily measured, therefore collecting data that reflects a positivist stance would be challenging for this type of research. Additionally, the level of predictability from a creative process, such as insight discovery, is probably not conducive to a positivist stance.	The subjective meaning and individual interpretation posited by constructivism does not lend itself to the study of customer insight discovery, as the identification of a process would posit that there is a certain degree of commonality between individuals' interpretation, and it could be objective.	As customer insights can be socially constructed and not universal truths but can be generalised the critical realism philosophy approach is considered most suitable for the current research.

Source: Adapted from Denzin and Lincoln (2011)

Figure 3-1: Research Design Flow



Source: Author

3.3.2 Conclusion of Philosophical Perspectives

Reviewing the philosophical perspectives enables certain decisions to be made regarding the current research. Research in the social sciences frequently investigates phenomena that cannot be easily measured or observed, such as creativity, decision-making, or problem-solving. The current study investigated a social phenomenon - the discovery of customer insights by innovation teams. As the actions involved are cognitive, the researcher could not easily observe cognition, which can occur at unpredictable times and events; therefore, a positivist perspective was rejected. In considering constructivism, as results and findings are interpreted subjectively, it is challenging to separate bias from the researched phenomena. Therefore, a constructivist philosophical stance is not suitable for the current research as the researcher prefers to remain outside of the investigation, as an outside perspective may assist the researcher in generalising the findings across other organisations and industries. Though the research precludes objectivity from a positivist standpoint, constructivism is considered too subjective. The current study proposed an objective meaning and interpretation of social phenomena for the collection and analysis of data, whereby the researcher interviewed participants to understand how they discover new customer insights without being involved in the participants' activities and thoughts. Additionally, though the research results and findings aim to be generalisable across cases and industries, this is challenging as a single industry and company have been used for the study.

The RQs suggest that a critical realist perspective would be most appropriate to investigate the phenomenon. The reasoning behind this choice is, firstly, it is suitable for use with how and why research-type questions, and secondly, it is suited to understanding casual relationships. Yin (2018, p. 9) stated that the "form of the research question directs the researcher to a research method"; refer to Table 3-2.

Table 3-2: Method and the Form of a Research Question

Research Method	Form of a Research Question
Experiment	How? Why?
Survey	Who? What? Where? How many? How much?
Archival Analysis	Who? What? Where? How many? How much?
History	How? Why?
Case study	How? Why?

Source: Adapted from Yin (2018 p.9)

Critical realism shares with positivism an objective knowledge about the world. It also agrees with constructivism that people give meaning to the world, and they somewhat construct their worldview. As the researcher is a trained mechanical engineer and designer, the positivist side of the philosophical spectrum is appealing – solving complex engineering challenges creates a single positive result that objectively answers the problem. However, engineers also know that many possible solutions can be used to solve the same problem, and their skill becomes evident when an engineer balances the competing wants of society to create the most desirable, feasible and economical solution. Therefore, unlike scientists, engineers understand that pursuing a positivist perspective, where a single objective theory is a goal, is not always possible and that a successful solution to a problem may be socially constructed. Engineering is not the pure application of scientific discoveries, as such technology "is co-determined by social, cultural, economic and technical factors in the environment that contextualises it" (Hatch and Cunliffe, 2006, p. 155). This is reciprocal as technology then influences society and culture and, therefore, is the means of radical social change.

Additionally, the critical realist perspective links to the RQs. As such, this philosophical approach is suitable to answer RQ 1, as it tries to find the underlying relationship between the two concepts. Furthermore, RQ 2 attempts to understand and describe the human objective meanings and interpretations around the social phenomena of customer insight discovery. Accordingly, the research will adopt a critical realist philosophical perspective, representing an essential middle ground in social science between positivism and constructivism.

3.4 THEORETICAL PERSPECTIVE

As a vital component of PhD research, contributing to an existing theory is crucial. The systematic literature review (SLR) that was conducted introduced the FEI theory (Section 2.3.3), which included the two main theoretical frameworks from (Khurana and Rosenthal, 1998) and (Koen *et al.*, 2001). The utilisation of these frameworks confines the research to the front end. These theories will be utilised in the data analysis. The research will be built around them. However, the frameworks need to explain how needs and insights develop over time in the FEI. In addition to using the FEI theoretical framework as a lens for analysis, a specific management theory will also be applied to comprehend the cognitive aspects of the FEI; the selection of an applicable management theory is discussed in the next section.

3.4.1 Management Theories

Several management theories were considered to understand which would suit this cognitive aspect of the research. The list of theories was drawn from various sources. The first source was the 19 empirical studies from the SLR that researched customer needs and customer insight; refer to Table 2-2. Fifteen of the studies did not state a theoretical lens; however, the remaining four did state a theoretical lens: resource-based view, market orientation, market-based organisational learning, and absorptive capacity. Secondly, other management theories were sourced from two primary references to cast a wider net: 1) Great Minds in Management Field (Smith and Hitt, 2005) and 2) The Little Book of Big Management Theories (McGrath and Bates, 2017). These theories are summarised, and their relevance to customer insight in product innovation is reviewed in Table 3-3.

Table 3-3: Management Theories[2]

Theory	Authors	Summary	Applicability of Theory to the Study of the FEI
Absorption Capacity	Cohen and Levinthal (1989)	Absorptive capacity is a firm's ability to assimilate new information and apply it commercially. It is to be a reason for companies to invest in R&D, as internal R&D teams increase the absorptive capacity of a company.	A product innovation team conducting customer needs and insight activities is bringing external knowledge internal.
Action Theory	Frese and Sabini (2021)	Action theory was developed in applied psychology; it defines goal-oriented behaviours and the task-oriented view of human behaviours by describing how tasks are completed. The theory consists of the following steps: 1) development of goals and decision between competing goals 2) orientation including prognosis of future events 3) generations of plans 4) decision to select a particular plan 5) execution and monitoring of plans and 6) feedback process.	Applicable as innovation team are goal and task-oriented problem solvers.
Agency Theory in Management	Eisenhardt (1989a)	Agency theory defines the relationship between how a person (principal, owner, shareholders) delegates work to another (agent, top management), and tried to explain how problems can occur within the relationship. It explains the following: conflict between the principal and agent regarding goals and goal verification expense for the principal and differences in risk acceptance level for both parties.	Applicable as innovation teams act within a larger hierarchical and/or matrix organisations. Their command and relationship may drive the interpretation of needs in the FEI.
Actor Network Theory	Callon (1986)	Actor network theory explains the relationship and interactions of organisations, managers, and employees within a network. The network has three dynamic phases; Emergence, Development and Stabilisation.	Applicable as innovation teams act within a larger hierarchical and/or matrix organisations. Their network may drive the interpretation of needs in the FEI.
Affective Event Theory	Weiss and Cropanzano (1996)	Explains that individuals' emotions, reactions, and experiences are important in the workplace situations. And this influences workplace behaviour and attitudes.	Applicable as innovation teams may feel emotional events when insights are discovered.

[2] This table links to Table 2.2, which contains the theoretical perspectives of the empirical papers.

Theory	Authors	Summary	Applicability of Theory to the Study of the FEI
Attribution Theory	Harvey and Weary (1984)	Theory describes two types of attributions. The personal (internal) attribution explains personal characteristics (ability, personality, mood, efforts, attitude); situational (external) attribution is situational factors (tasks, others).	Applicable as innovation teams have to use their personal characteristic (internal) when interacting with customers and analysing the market research data (external).
Cognitive Dissonance Theory	Festinger (1957)	People need consistency and dissonance is caused when there is an inconsistency between attitudes and action. Attitude tend to change to match behaviours.	Insight may be discovered when there is a change in the innovation teams' original thinking that is changed when new data is found.
Chaos Theory in Management	Lorenz (1963); Peters (1987)	Relationships in complex and adaptive organisations are non-linear with many interconnections and divergent choices which creates unintended effects. Managers cannot measure, predict, or control this randomness.	Applicable as innovation teams act within a larger hierarchical and/or matrix organisations. The fuzzy FEI has been reported as random.
Contingency Theory	Woodward (1958)	There is no best way to structure an organisation. Organisations need to act contingent on both the internal and external situation that exist at certain times.	Applicable as the FEI has been reported as random; the innovation team structure may change to deal with new knowledge.
Double Loop Learning	Argyris (1985)	When errors are detected, the correction involves deeper changes to the policy and practices and not just correcting the error (single loop learning).	Applicable as an error could be interpreted as a change in understanding due to the innovation team receiving new knowledge, consequently learning, and adapting.
Expectancy Theory	Vroom (1964)	A person behaves depending on their motivation with the result of the behaviour and desirability of the outcome.	Applicable as innovation teams may be motivated to find new insights that lead to more desirable outcome for themselves in the innovation.
Goal Setting Theory	Locke and Latham (1990)	The highest level of performance is achieved when goals are both clear, specific, and challenging.	Applicable as in the FEI as a challenging process and innovation teams are set a goal to understand the market and deliver a set of needs and insights.

Theory	Authors	Summary	Applicability of Theory to the Study of the FEI
Knowledge Management Theory	Nonaka (1994)	Knowledge is created through the interaction between tacit and explicit knowledge. The SECI model states four steps: (1) from tacit knowledge to tacit knowledge, or socialisation; (2) from tacit knowledge to explicit knowledge, or externalisation; (3) from explicit knowledge to explicit knowledge, or combination; and (4) from explicit knowledge to tacit knowledge, or internalisation.	Applicable as needs and insights are defined as the creation of new explicit knowledge from understanding the tacit knowledge of the customers.
Market orientation	Narver, Slater and MacLachlan (2004)	Market orientation is the organisational culture consisting of, customer orientation, competitor orientation and inter-functional coordination The culture most effectively and efficiently creates the necessary behaviours for the creation of superior value for buyers and, thus, continuous superior performance for the business.	Applicable, as the FEI is the activity of learning about the market and customers. As such this is directing effort towards the market, so the team is oriented to the market.
Market-based learning	Sinkula (1994)	MBL theory perceives the customer insight process as having four key stages: identifying insight needs, acquiring and, transforming the needed market information, dissemination of this insight across the organisation, building a shared interpretation, storage of insight into organisational memory.	Applicable, as the FEI is the activity of learning about the market and customers.
Resource Dependence Theory	Pfeffer and Salancik (1978)	How the organisation's external resources affect the behaviour of the organisation. The procurement of external resources is important for strategic and tactical management.	Applicable as external resources could be defined as the market and customers, so these resources affect the organisations strategy and how they conduct the FEI.
Resource-Based View Theory	Barney (1986)	Organisational resources enable them to achieve competitive advantage; a subset can lead to the creation of competitive advantage and superior long-term performance. Resources that are valuable, rare, in-imitable, and non-substitutable (VRIN).	Applicable as the resources in the front end team can be key to discovering insights that provide the company with a competitive advantage.

Theory	Authors	Summary	Applicability of Theory to the Study of the FEI
Sensemaking Theory	Weick (1995)	Process by which people give meaning to their collective experiences. Shared meaning of experiences, environment, and perspectives within an organisation.	Applicable as innovation teams could use sensemaking to understand the new knowledge (market research data) that is collected in the FEI and discover insights.
Componential Theory of Creativity	Amabile (1988)	Model proposes three dominant components of creativity: domain-relevant skills, creativity-relevant skills, and task motivations.	Applicable, as creativity and the innovation team motivations are key attributes in the FEI.

Source: Author

Seventeen of the 19 theories that were considered for their applicability to the FEI were found to be of limited value for the research. They were initially considered for inclusion as they could apply to the FEI. Still, after a deeper review, they were found not to explain the intricacies of the process for the discovery of customer insights. However, two theories did show applicability and have been utilised by previous authors Nonaka's Knowledge Management (Sakellariou, Karantinou and Goffin, 2017) and Weick's Sensemaking theories (Drazin, Glynn and Kazanjian, 1999; Stigliani and Ravasi, 2012; Beverland, Micheli and Farrelly, 2016). These two theories and their applicability to the research will be discussed in detail in the next section.

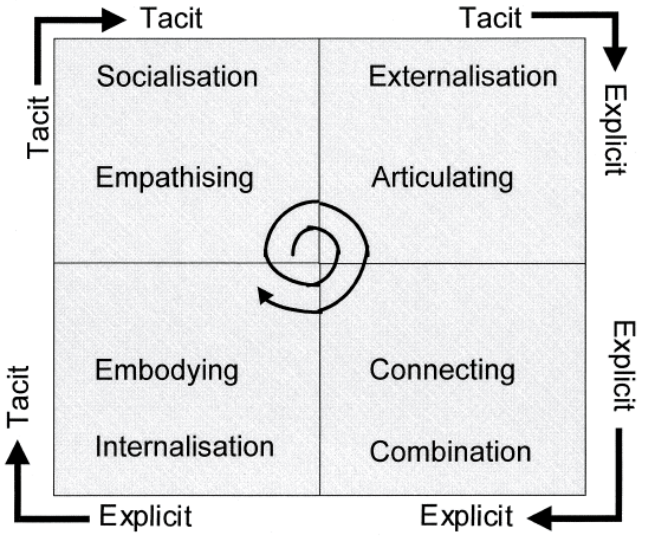
3.4.2 Nonaka's Knowledge Management

Nonaka described the theory of knowledge creation in organisations in 1994 (Nonaka, 1994). Nonaka proposed the four modes of knowledge management founded on the difference between the interaction of *explicit* and *tacit* knowledge. Explicit knowledge can be articulated, and it is codified knowledge that can be expressed in words, sentences, numbers, procedures, or formulas and, therefore, can be easily transferred. Tacit knowledge is subjective and experience-based; it cannot be easily expressed in words. It is beliefs, mental images, intuition, mental models, and technical skills such as craft and know-how. In product innovation, tacit knowledge is critical for developing successful products (Sakellariou, Karantinou and Goffin, 2017). Nonaka states that through social interaction, tacit knowledge can be converted into explicit knowledge, and as such, new knowledge is created (Nonaka, Toyama and Konno, 2000). To illustrate this, Nonaka (1994) proposed the SECI model (Figure 3-2) of knowledge creation to explain how tacit

knowledge is converted into explicit knowledge, and then explicit knowledge further creates new tacit knowledge. Four modes of knowledge creation that are expressed in the SECI model are:

- Socialisation – tacit to tacit transfer from person to person. An example of the technical aspect of this is the mentor-apprentice relationship. Another is the cognitive aspect, such as informal meetings and shared mental models.
- Externalisation – tacit to explicit. Tacit knowledge is converted into explicit knowledge by individuals sharing or codifying their knowledge through procedures, training, and design artefacts (prototypes, sketches). In addition, analogies and metaphors are often used to illustrate tacit knowledge.
- Combination – explicit to explicit. Explicit knowledge is shared through formal company meetings, reports, etc., whereby existing explicit knowledge is combined with new interpretations.
- Internalisation – explicit to tacit. This stage is learning by doing and through experimentation, creating new ways of doing from the internalised knowledge. At this point, the successful and unsuccessful new ways of doing can be socialised.

Figure 3-2: SECI Model



Source: Adapted from Nonaka, Toyama and Konna, 2000.

As the individual works through the SECI modes, knowledge is passed from the individual to the team level onto the organisational level. This process is described as a

continuous spiral, with each pass creating higher levels of new knowledge. In the FEI of innovation, there is a large amount of tacit and explicit information gathered from market research activities. This new information, in turn, generates a large amount of new knowledge that involves a novel understanding of the field (Sakellariou, Karantinou and Goffin, 2017). This new knowledge can then be directed to the creation of new innovative products. Schulze and Hoegl (2008) showed that socialisation and internalisation were positively related when considering novel idea generation in the FEI; however, externalisation and combination were negatively correlated.

There has been criticism of Nonaka's theory of knowledge creation. Firstly, it begins with an individual already possessing the problem to be solved. Secondly, the model is based on limited empirical evidence; the case studies were performed in a Japanese company and may need more generalisation across countries and industries. Finally, the model was validated using surveys, which is considered limited for robust concept validation. However, the model does have the advantage of distinguishing between tacit and explicit knowledge. It also supports that new knowledge is a social learning process and, secondly, a creative process for individuals, teams, and organisations.

In sum, the model fits nicely into the study of the discovery of customer insights because the tacit knowledge (aha moment) requires explanation to the broader organisation. However, the concern is that the discovery of insights follows the SECI flow, but this may need to be more disordered, with the team moving back and forth between explicit and tacit knowledge.

3.4.3 Sensemaking

The following section will briefly introduce *sensemaking theory* and review specific papers on sensemaking in creativity and innovation. Sensemaking theory aims to understand and describe how people develop meaning (Weick, 1995). It is a process whereby people try to organise and rationalise their environment to "understand issues or events that are novel, ambiguous, confusing, or in some other way violate expectations" (Maitlis and Christianson, 2014, p. 57). To do this, people use cues or triggers to find meaning that informs and constrains their identity and actions (Weick, Sutcliffe and

Obstfeld, 2005). Sensemaking begins when the current state of the world differs from expectations; people then hope to find the right action or pathway to seek clarity and meaning. Sensemaking occurs when there is either a difference in experience or an unexpected event, which causes people to ask, what is going on here and what should they do next? (Maitlis and Christianson, 2014). This process is not just an interpretation of events. It goes further into comprehension and a deeper understanding of the event. It has been stated that sensemaking occurs as a social process when people within groups iteratively generate a collective meaning as each person influences the other. It also suggests a temporal orientation to sensemaking as the repeated cycles occur within the group over time (Maitlis and Christianson, 2014).

In the creativity literature, collective meaning has also been referred to as collective creativity (Hargadon and Bechky, 2006); group members utilise their past experiences to reframe problems that lead to new valuable insights. Sensemaking is seen as a positive influence on creativity (Christiansen and Varnes, 2009; Wright *et al.*, 2000). From a sensemaking perspective, Drazin, Glynn and Kazanjian (1999, p. 287) defined creativity as a process rather than an outcome, whereby people engage in creative acts as they "attempt to orient themselves to take creative action in situations or events that are complex, ambiguous and ill-defined". Maitlis and Christianson (2014) also proposed a process model that focuses on creativity as a process rather than an outcome - the outcome being a judgement of the artefact's novelty and usefulness. The model explains that creativity occurs at three levels (individual, group, and organisation) and that each has a different creative activity. However, in both the creativity and innovation literature, the study of sensemaking is still under development (Drazin, Glynn and Kazanjian, 1999; Stigliani and Ravasi, 2012; Beverland, Micheli and Farrelly, 2016). Sensemaking has been reported to "create linkages between elements of these equivocal frameworks that, in turn, allow the emergence of novel accounts of the organisation and ways of doing business that trigger and facilitate innovation" (Maitlis and Christianson, 2014, p. 93). This theory fits well with product innovation; a novel approach is central for imagination and expressiveness to be successful (Rylander Eklund, Navarro Aguiar and Amacker, 2021).

Relating sensemaking to product innovation, Rylander Eklund, Navarro Aguiar and Amacker (2021, p. 32) stated that the "word *sense* allows the integration of both the

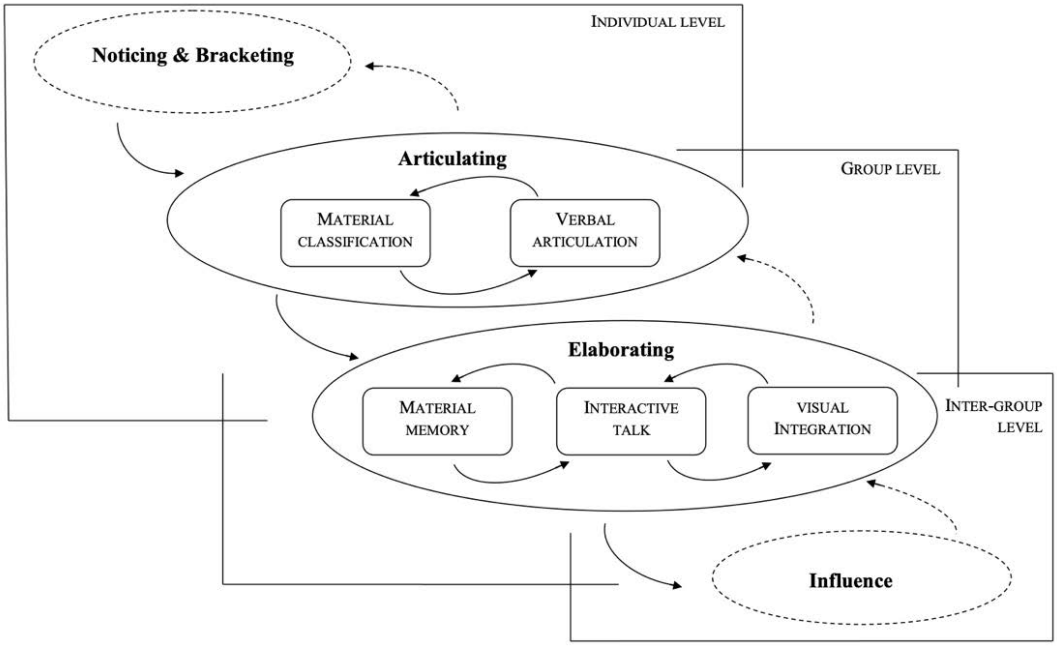
cognitive and emotional aspects of the human experience in interaction with the environment". Sukhov *et al.* (2021) also applied sensemaking theory to the FEI and showed how experts screened and selected ideas with sensemaking seen as a goal for developing meanings. Griffith (1999) researched the introduction of new technologies to users at the end of the innovation process. They proposed a model of the features-based theory of sensemaking triggers (FBST) within the broader diffusion of innovation field (Rogers, 2003). Triggers are essential to initiating sensemaking, as noticing emerging technologies involves ongoing structuring. Dougherty *et al.* (2000) proposed a sensemaking system to link market and technology knowledge to new products. This sensemaking system couples the tension between tacit and articulated knowledge into a new understanding of innovation. They found that the most innovative companies "construct, bracket, interpret and rethink market and technology knowledge" (Dougherty *et al.*, 2000, p. 342).

Stigliani and Ravasi (2012) reported on an ethnographic study with a product design firm. They found team members used various material artefacts (magazines, sketches, prototypes) to build their understanding of the future. They proposed a sensemaking model that situates the future collective process with retrospective iterative cycles, whereby people are "required to develop novel understandings and engage in forward-looking thinking" by articulating and elaborating new mental structures (Stigliani and Ravasi, 2012, p. 1234). The model showed how the retrospective aspects of noticing and bracketing move through to prospective articulation and elaboration. This combined retrospective and prospective view builds on the original retrospective theory of sensemaking. The model has four phases, shown in Figure 3-3:

- Phase 1: Noticing and Bracketing - context, cues, and immersion in the data.
- Phase 2: Articulating - tentative new understandings. It involves listing features, creating metaphors, producing prototypes, conceptualisation, and visualisation, which imbue the experience with meaning. Also, bucketing - grouping and regrouping of artefacts and ideas.
- Phase 3: Elaborating - new complex mental structures involving group meetings, sharing, and integration, refinement, preservation, and recovery of emerging structures.

- Phase 4: Influencing – Confidence in the interpretations to present to others, sense-giving.

Figure 3-3: Process Model of Collective Future-Oriented Sensemaking



Source: Adapted from Stigliani and Ravasi 2012.

Considering the product innovation sensemaking articles that have been reviewed, the paper by Stigliani and Ravasi (2012) has similarities to the present research. The theory proposed that individuals exchange their understanding and try to agree on consensual interpretations and a course of action, feeding each other and building meaning. This is a social process of collective meaning-making and problem-reframing. This future-orientated collective process, combined with a retrospective individual cognition, is similar to how an individual reviews market research, shares ideas and builds upon those ideas to discover insights.

The paper investigated the design process and the creation of tangible artefacts. Stigliani and Ravasi (2012, p. 1232) stated that the visual nature of the process creates "material practices (drawings, prototypes, slide presentations) that support the conversational practices through which they exchange, combine and construct interpretation". This parallels the innovation team's work in the FEI, where they create prototypes to inform each other of their ideas. The FEI has been defined as an ambiguous environment. Ambiguity leads to prospective sensemaking and a novel understanding.

Innovation teams also face ambiguity regarding market research data and the discovery of customer insights. They perform cognitive looping between the market research data and provisional and emerging interpretations. The time component is crucial in the FEI: "Time is more relaxed, providing an opportunity for the prolonged and conscious articulation and elaboration of tentative interpretations" (Stigliani and Ravasi, 2012, p. 1250).

In conclusion, sensemaking theory has been empirically tested with multiple cases and cultures and is an established theoretical lens. The studies showed that sensemaking theory has been applied to creativity and product innovation. Teams look forward to understanding how current knowledge can be used to make sense of the new envisioned environment and, as such, create a more profound understanding to address this new future environment. The theory suggests that sensemaking begins when teams try to make sense of new data and envision the future environments that customers may face. It explains how people respond to the unknown. Within sensemaking theory, individuals ask, "What is going on?" (Maitlis and Christianson, 2014, p. 72). This is comparable to how front end innovation teams intentionally approach the discover insights to make sense of customer words and actions.

3.4.4 Summary of the Theoretical Perspectives

After reviewing 19 different management theories, it was determined that Nonaka's SECI model and sensemaking were the most appropriate for research into the discovery of customer insights. While Nonaka's SECI model may be useful, its tacit/explicit/tacit knowledge flow could be too rigid. Thus, a more flexible model is likely more appropriate. As such, the current study employs the collective future-oriented sensemaking process model, which is an existing sensemaking theory. To apply this model, a thorough reading of the Ravasi and Stigliani (2012) paper was conducted to extract key terms. These terms are included in the provisional sensemaking coding list found in Appendix B.2, which is helpful for initiating the data analysis coding process. The present study aligns with the existing front end of innovation theories and uses a sensemaking lens to analyse the cognitive activities that occur during this stage.

3.5 RESEARCH DESIGN APPROACH

The research aims to understand how customer needs are related to customer insights and how innovation teams discover those insights. The literature review pointed to an emerging and complex phenomenon and limited established theory regarding the problem. This suggests utilising exploratory research. The considerations of this choice are explained in the following sub-sections.

3.5.1 Consideration of Research Design

When choosing the most appropriate research design, it is essential to consider the data collection approach to answer the RQ effectively. This comprises deciding whether a quantitative, qualitative, or mixed-method approach should be used. These three approaches are discussed.

Quantitative methods typically involve numerical data to understand the relationship between dependent and independent variables. As large data sets are frequently used in quantitative methods, statistical tools can be used and as such, generalisability is easier to achieve compared to qualitative methods. However, due to the aggregated data, the richness of understanding and meaning can be lost. Thus, as the current research investigated customer insights, quantitative methods are not appropriate as the deeper meaning may be abstracted by the data analysis (Denzin and Lincoln, 2011).

On the other hand, qualitative methods involve analysing non-numerical data, such as data from interviews and observations. These methods allow the researcher to understand the participants' views in depth. By exploring their lived experiences, the researcher can dig deep into the meanings behind decisions and actions (Denzin and Lincoln, 2011). However, data collection using qualitative methods can be time-consuming, and generalisability is limited due to the typically small sample size.

Mixed methods, meaning the use of both qualitative and quantitative methods in a single study, have been proposed to reduce the limitations of each approach. However, mixed methods also present challenges because data collection time can increase and analysing both the qualitative and quantitative data it is not easy to produce a coherent narrative. The conclusions of the results are also complex (Denzin and Lincoln, 2011).

3.5.2 Conclusion of Research Design Approach

As this research is exploratory, an approach most appropriate to exploration is essential. Furthermore, the research focuses on a social problem studied in a natural environment. Therefore, from a critical realist philosophical stance and considering the exploratory nature of the research, Creswell et al. (2007) suggested a qualitative approach. Additionally, Symon and Cassell (2012) stated that qualitative research is suited to emergent research. Therefore, a qualitative approach is selected.

3.6 DATA COLLECTION APPROACH

Now that a qualitative research approach has been selected, the next step in defining the research design is choosing the data collection approach. Yin (2018) suggested that case studies, ethnography, or action research are appropriate data collection approaches for a qualitative exploratory study. Each of these will be discussed below. This section will then conclude with the justification of the selected method.

The case study is a focused evaluation of a bounded situation or system; it involves collecting data from observations in the field, such as geographical, location, workplace or organisation (Bryman and Bell, 2007; Yin, 2018). Case study researchers typically select qualitative methods such as participant observation or semi-structured interviews. In case study research, the researcher investigates organisations from within so that they are "exposed to real problems … people at all levels of the organisations and the varied contexts of the cases" (Karlsson, 2016, p. 166). Yin (2018) proposed that a case study is useful when 1) investigating a broad and complex phenomenon in real-life settings, 2) when the existing literature is limited, and 3) in-depth investigation is required. A case study involves collecting data on critical real-life events (Yin, 2012), as the "overriding warrant for qualitative research is that researchers get close to the life worlds of those studied" (Easterby-Smith, Golden-Biddle and Locke, 2008, p. 423). The case can be an individual, an organisation, a process, or an event taken from a viewpoint in place and time, and this is referred to as the unit of analysis (which is explained later in the chapter). Furthermore, along with historical case studies, case studies can also be used to investigate contemporary phenomena, providing rich data on processes that emerge over time and are most appropriate for answering how and why questions (Pare, 2004). It can

be time-consuming to collect the data, but it does provide a deeper understanding of exploratory research as it uses multiple data sources to triangulate findings.

Ethnography is a method of "direct observation of a particular phenomenon of interest, the interpretation of those observations and the description written in the context of the whole environment" (Partington, 2002, p. 117). It attempts to find an explanation of meaning within the context of the enquiry by studying small populations in unusual or inexplicable situations. Theory is built through iterative data collection and analysis. However, ethnography research remains within the context and does not try to generalise. Therefore, ethnographic research may present a challenge in this type of research, as customer insight may not be discovered during the observation period. Additionally, observation, such as within the workshop, may create a false environment for the participants.

In action research, the researcher directly participates in an organisational change and simultaneously investigates the problem. Therefore, the outcome is an action and research-based knowledge (Karlsson, 2016). Action research is "a process in which applied behavioural science knowledge is integrated with existing organisational knowledge and applied to solve real organisational problems" (Karlsson, 2016, p. 234). It has been likened to management consultant practice in large organisations, but it differs from consulting by adding the research element. However, action research can be difficult to generalise, and the action aspect may be extensive and challenging to complete in a reasonable time frame (Coughlan and Coghlan, 2002).

The advantages and disadvantages of each data collection method described above are summarised in Table 3-4. In addition, the table also provides a summary of how each method relates to the proposed research design.

Together with the qualitative methods discussed above, the research should consider the reasoning approach - *inductive, deductive,* and *abductive*. Inductive reasoning makes broad, probable generalisations from a limited number of observations. Deductive reasoning is the opposite of inductive; it builds on theory by starting with a hypothesis and trying to test this hypothesis. Deduction is the basis for the scientific method. Finally, abductive reasoning tries to find the likeliest explanation for a given phenomenon from a set of observations (Baggini and Fosl, 2010).

Table 3-4: Qualitative Research Methods

Method	Advantages	Disadvantages	Related To the Present Research
Case Study	Applicable for investigating specific phenomenon Contextual in depth Flexible data collection Can generate hypothesis Natural setting	Difficult to generalise Subject to cultural bias, dependent on case selection Time consuming Data overload	Ability to present evidence on a rare phenomenon, such as customer insight discovery and illustrate the conceptual framework. By utilising cases across multiple organisations, a generalisable framework could be developed.
Ethnography	Investigate complex social phenomenon Understands the feelings and ideas of people who are experiencing the event Contextual in depth Uncover data on a subject that cannot be reported Data collected as it happens	Not generalisable Time-consuming and maybe costly Subjective Observers are fallible	Observing the participants may not be possible as customer insights may not be discovered in a controlled observable environment, such as a workshop.
Action Research	Research in action, rather than research about action Participative Concurrent with action A sequence of events and an approach to problem solving	Lacks the required rigor of academic research Time-consuming Lack of impartiality on the part of the researcher Difficult to claim external validity	The researcher being actively involved may bias the data collection and could lead to an incorrect interpretation for the framework.

Source: Adapted from Yin (2012) and Easterby-Smith, Golden-Biddle and Locke (2008)

3.6.1 Conclusion of Data Collection Approach

When selecting the most appropriate research method, it is essential to consider the RQs. These research questions are both how questions, and according to Yin (2012), these are suitable for qualitative research methods. As such, the research investigates a complex emerging phenomenon and, therefore, requires an in-depth exploratory approach. An exploratory approach is also suitable as the literature review did not clearly show an agreed conception of customer insights and has limited theory describing the phenomenon. In deciding upon the most appropriate data collection approach, the

challenges that the RQs present and the current research environment must be considered. It is challenging for the researcher to directly observe a participant discovering customer insights, as there is a limited signal to the event's precursor. Furthermore, it has been reported in the psychology literature that predicting when insight will be discovered may not be possible (Davidson, 1995). Insight may be discovered hours, days or weeks after the market research data is analysed so that the research may miss the critical data (Hargadon and Bechky, 2006).

Therefore, given the qualitative research methods discussed above, an *inductive case study* is the most suitable for exploratory research, as it could present evidence on a rare phenomenon and illustrate the conceptual framework. A case study is well suited to investigate the emerging phenomenon. Furthermore, a generalisable framework could be developed by utilising cases across multiple projects. This research takes an inductive approach, whereby specific case studies are used to generate theory.

3.7 SUMMARY OF THE RESEARCH DESIGN CHAPTER

This chapter has considered the research design choices, the RQ, consideration of the philosophical perspective, the research method, the data collection approach, and the theoretical perspective. The review concludes that an exploratory qualitative approach is most appropriate for the research.

This decision was also confirmed following the review of the philosophical perspectives, which resulted in the choice of a critical realist stance. This represents a middle ground in social science between positivism and constructivism. Furthermore, critical realism links with the RQs and is suitable for finding the underlying relationship between needs and insight. Accordingly, the research will adopt a critical realist philosophical perspective.

In considering data collection, an *inductive multi-case study* was chosen to be the most suitable for exploratory research due to its ability to present evidence on a rare phenomenon. Furthermore, a generalisable framework could be developed using cases across multiple projects. Therefore, a multi-case study is well suited to investigate the emerging phenomenon. The research takes an inductive approach, whereby specific case studies are used to generate theory. Finally, a theoretical sensemaking lens was selected,

particularly the collective future-oriented sensemaking process model. The next chapter (Chapter 4) will build on the research design and propose the research method that will be used for the study.

CHAPTER 4 RESEARCH METHOD

4.1 INTRODUCTION

The previous chapter (Chapter 3) presented the choice of an inductive multi-case study for the research design. Chapter 4 considers the research method, the details of the chosen techniques for data collection and the data analysis of the case studies. For instance, who and what will be part of the research (unit of analysis, sample selection, data collection), and how will the data be analysed? This chapter will also discuss the feasibility and pilot case studies, expected findings, and contributions. Chapter 4 is organised into the following sections:

- Case study method
- Unit of analysis
- Sample selection
- Data collection sources
- Data analysis
- Validity and reliability considerations
- Feasibility study and pilot case study
- CASET assessment
- Summary of the research methodology

4.2 CASE STUDY METHOD

The case study method offers two options: retrospective and longitudinal approaches, each with its advantages and disadvantages. Retrospective case study involves analysing past cases to understand the processes, challenges, and outcomes. This is crucial for comprehending the complexities and nuances of the FEI. It allows researchers to learn from previous successes and failures, providing valuable insights for future endeavours. In product innovation, this involves analysing completed projects to identify critical

factors that contributed to their success or failure, providing a comprehensive view of the entire process.

However, one of the challenges of a retrospective case study is the reliance on historical data, which may be incomplete or biased. Researchers must be cautious in their data collection and interpretation to ensure a balanced and objective analysis. Additionally, there can be limitations in generalising findings from case studies to broader contexts (Yin).

A longitudinal case study in product innovation involves studying the same set of subjects over an extended period (Pettigrew, 1990). This method is particularly effective in understanding the evolving nature of product innovation, capturing the dynamics of change (Perks and Roberts, 2013), and exploring the deep contextual factors that influence this process. Product innovation is inherently dynamic, often involving complex interactions over time (Eisenhardt and Graebner, 2007). Traditional cross-sectional retrospective studies, while helpful, may only partially capture the evolving nature of innovation. Longitudinal research allows researchers to observe changes and developments as they occur, offering richer insights into the innovation process (Ployhart and Vandenberg). Authors like Leonard-Barton (1990), in her work on developing new technology in organisations have emphasised the importance of understanding these dynamics over time. Longitudinal case study research in product innovation offers a comprehensive and dynamic view of the innovation process. It allows researchers to delve into the complexities and intricacies of how the process evolves and is influenced by many factors over time.

Integrating retrospective and longitudinal case study research methodologies in a dual study provides an in-depth and comprehensive approach to understanding a complex phenomenon (Leonard-Barton, 1990). By combining these methods, researchers gain a broader perspective, beginning with the historical foundation established by the retrospective study and deepening the exploration through the longitudinal approach. This integrative approach offers numerous advantages, such as establishing a detailed timeline of events and enabling a more robust analysis of relationships that have influenced the case's progression over time. The insights gained from this approach can shed light on how specific factors or decisions have impacted the case, leading to the development of

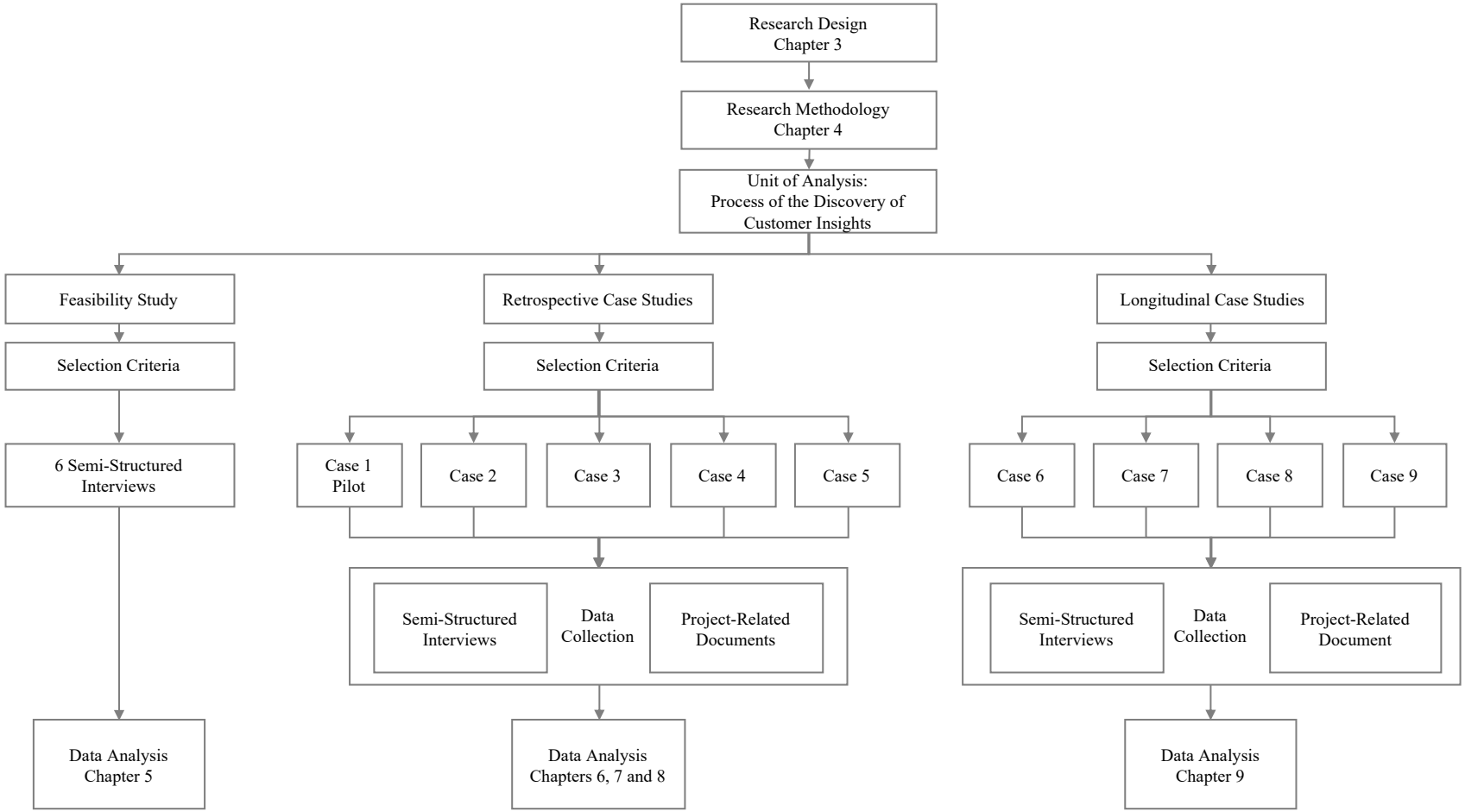
more nuanced theories and models. Ultimately, this broader perspective and multi-faceted data analysis can lead to a deeper understanding of the case's underlying dynamics and contribute to the advancement of knowledge in the field.

Furthermore, this dual approach was advantageous as it provided data on innovation projects from two perspectives (Leonard-Barton, 1990). Firstly, the retrospective case studies gave the historical view of a completed project and allowed the researcher to dig deep into how an innovation team discovers customer insights. Secondly, the longitudinal case studies provided the opportunity to explore how customer insights developed dynamically during the FEI of a project (Perks and Roberts, 2013). Additionally, by taking the longitudinal approach, the researcher could get closer to the phenomenon of interest than by only using the retrospective approach because longitudinal research can "unravel the underlying dynamics of phenomena that play out over time" (Siggelkow, 2007, p. 22).

Moreover, the research aimed to understand how customer needs are related to customer insights and the process for the discovery of customer insights. The research was dependent on a customer insight emerging during the FEI process; therefore, combining a retrospective and longitudinal case study approach has been chosen to mitigate the risk that the cases would not discover customer insights (Khurana and Rosenthal, 1998; Frishammar *et al.*, 2016). The addition of the longitudinal approach also allowed the study of a case "at two or more different time points", this is important as this approach showed how the process developed time (Yin, 2018, p. 51). Moreover, to further mitigate the risk of the case studies not discovering an insight, two additional activities were undertaken firstly, a feasibility study (refer to Chapter 5) and secondly, only projects that were classified as transformational (see Section 4.4.1 for the explanation of case study selection) have been selected.

Data collection from both strands (retrospective and longitudinal) occurred concurrently depending on the researcher's and participant's availability, as seen in Figure 4-1: Overview of Research Approach. A multi-case study approach was designed with 1) Five retrospective case studies and 2) four longitudinal case studies. The following sections will justify the sample selection and specific data collection methods.

Figure 4-1: Overview of Research Approach, Sample Selection and Data Collection



Source: Author

4.3 UNIT OF ANALYSIS

Defining the *unit of analysis* (UoA) is a crucial decision in case study research as it bounds the research and focuses the researcher on the critical data for answering the RQs (Miles, Huberman and Saldana, 1994). The UoA can be individuals, groups, artefacts, geographical teams, social interactions, or processes. For instance, if the UoA is a process, then the interview guide used for interviewing participants should investigate the process, not the individuals involved (Yin, 2018).

Based on the RQs (found in Section 3.1) for this study, the UoA is the *process of the discovery of customer insights* in product innovation. This unit of study was chosen because the research aimed to explore how customer insights are discovered and reveal the relationship between customer needs and customer insights. The research was conducted during the FEI. The FEI is when the team collect and analyses market research data, uncovers customer needs and potentially discovers customer insights.

4.4 SAMPLE SELECTION

The following sub-section reviewed the sample selection; this includes the justification for the number, criteria, chosen number, type of case study, and interview participants.

4.4.1 Sample Selection Justification

The selection of an empirical sample for a study is challenging for this type of qualitative exploratory research. Firstly, it is constrained by what is reasonably feasible in terms of time (Symon and Cassell, 2012). Secondly, it is difficult for cases to be chosen randomly (Eisenhardt, 1989b), as the choice of each case study will attempt to predict similar results (literal replication) (Yin, 2018). Thirdly, access to sensitive and confidential company data on product innovations prohibits random samples from a given population from being selected. Therefore, deliberate case selection and theoretical sampling have been utilised (Miles, Huberman and Saldana, 1994).

The literature review showed that most previous empirical studies involved multiple case studies and were retrospective. Accordingly, the research employs a retrospective multi-case and also a longitudinal multi-case sample as this wider lens

allowed for a robust descriptive theory development (Christensen, 2006; Yin, 2018). Furthermore, the choice of multiple case studies had the advantage of being "directly analogous to that used in multiple experiments" (Yin, 2018, p. 55). It allowed for the investigation of similarities or differences across cases. No previous studies have employed a combination of a retrospective and longitudinal research approach; this combination provided a deeper understanding of the insight discovery process.

4.4.2 Number of Samples Selected

The number of case studies was determined before starting the data collection. For the number of cases, the judgement will be a "discretionary, not formulaic one" (Yin, 2018, p. 59). The selection of an empirical sample for the study is challenging for this type of qualitative exploratory research. Firstly, it is constrained by what is reasonably feasible in terms of time (Symon and Cassell, 2012). Secondly, it is difficult for cases to be chosen randomly (Eisenhardt, 1989); the choice of each case study will attempt to predict similar results (literal replication) (Yin, 2018). Thirdly, access to sensitive and confidential company data prohibits random samples from a given population from being selected. Therefore, deliberate case selection and theoretical sampling have been utilised (Miles, Huberman and Saldana, 1994).

Yin (2018) indicates that two or three case studies can aim at being literal replications. Therefore, the research has five studies for the retrospective strand and four cases for the longitudinal research strand (Pettigrew, 1990). The choice of a higher number than recommended by Yin (2018) was purposeful to mitigate risks. The risks that were considered were: 1) one or more of the longitudinal innovation projects may have been cancelled, 2) one or more of the longitudinal innovation projects may not have discovered a customer insight, and 3) the case participants may not have been able to articulate the process adequately.

Data collection concluded when *theoretical saturation* was reached (Strauss and Corbin, 1994) and the emerging theory was developed (Symon and Cassell, 2012). This is the point at which incremental learning becomes negligible. Theoretical saturation was achieved with three case studies; however, all cases were reported.

4.4.3 Sample Selection Criteria

The selection criteria have been chosen to ensure that the research engaged the projects in which the insight discovery process would be most likely to occur. The first criterion attempted to select a project that has the potential for the discovery of insights, so incremental projects are thus excluded; the second ensured that the research can engage the company in a timely and repeatable manner. The final criteria applied to only the retrospective cases. It attempted to engage projects that had recently passed the front end stage so that the participants had a relatively recent experience to talk about. The selection criteria are detailed, and their reason for inclusion is given in Table 4-1.

Table 4-1: Case Selection Criteria

Selection Criteria	Reason for inclusion	Application to case study approach
1. Product innovation is sufficiently radical and has the potential for the discovery of customer insights.	To ensure that the research investigates innovations where a customer insight was discovered. Otherwise, the case study may not have generated a customer insight, so it they may not be relevant information that the interviewee can provide.	Retrospective and Longitudinal.
2. The researcher has contacted and been granted access to confidential company information and can engage individuals.	To ensure that the data collection phase can use salient data.	Retrospective and Longitudinal.
3. For the retrospective strand of the research, the front end stage of the project was conducted within the last two years.	To reduce the tendency for post-rationalisation. The aim of selecting these types of projects is to ensure a recent innovative project is used for the case.	Retrospective.

Source: Author

4.4.4 Case Study Selection

4.4.4.1 Context of Case Studies

The case studies have been conducted at a multinational healthcare company that employs over 50,000 people worldwide, has over $50 billion in revenue and produces pharmaceuticals and medical technology. The organisation that has been studied,

MedDevCo, is structured in two divisions - surgical and orthopaedic devices. Four projects were from the surgical division, and five projects were in the orthopaedics division. These divisions are further broken down into business units. The selected businesses within the company unit were joint arthroplasty, trauma, laparoscopic surgery, wound care, and oncology. The business units were selected as the company is actively developing new products and working with customers, and the researcher had contacts in the business units. However, due to confidentiality and anonymity concerns, company details must remain high-level so the company cannot be easily identified.

Customer needs and insights sits within the FEI phase of product innovation. Many related activities occurred prior to the FEI, such as market discovery, invention, scientific discoveries and fundamental scientific research. The research does not explore the insights reported in these areas. Furthermore, the research does not cover the processes that occur after the FEI, such as new product development (NPD), diffusion of innovation, product lifecycle management or market development.

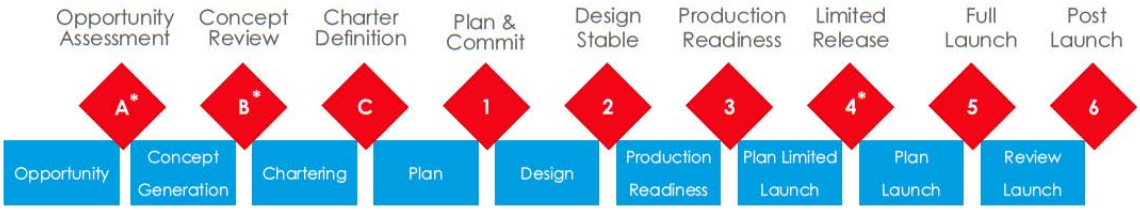
4.4.4.2 Finding the appropriate case

The selection of case studies was undertaken to find the innovation projects that fit the selection criteria. To do this, the organisation's project portfolio management software system, known as Cadence, was assessed. Cadence is a database of all active projects that are resourced with budget and headcount. The system also tracks various attributes for each project, such as *platform, project type, current phase gate* and the *project leader name*. Platform refers to the business unit, and there are 19 platforms in the medical technology organisation (for instance, joint reconstruction, endoscopic surgery, orthopaedic trauma, etc.). There are three project types tracked in Cadence - incremental, substantial, and transformational.

As well as a project portfolio management database, Cadence is also a product innovation stage-gate process. The organisation has nine phase gates that are based on the Cooper (2009) Stage-Gate process. The nine gates are split into three gates for the front end and six for the NPD phases; refer to

Figure 4-2. For the retrospective case studies, projects that are currently in Gate C, 1, 2 or 3 were selected. For the longitudinal case studies, projects at gates A and B were selected.

Figure 4-2: Cadence Process



The following steps were taken to locate the projects for the retrospective or longitudinal case studies:

1. The Cadence software system filtered the project list through gates A to 3. This produced a list of 140 projects. The list was then exported to Microsoft Excel with the following attributes – Project ID, Project Name, Project Type, Current Project Status, Approaching Gate, and Innovation Type.
2. The list was filtered using Excel with the Project Type column for the Incremental and Unfunded. These projects were excluded from the list. This filtering process resulted in 53 projects which were either Substantial or Transformative.
3. For the retrospective projects:
    a. The list was filtered with the Approaching Gate column for a project classified as gates C, 1, 2, or 3, resulting in 27 projects.
    b. The 27 projects were reviewed in detail in Cadence and ranked on the available descriptive information about the project. Twelve projects were tagged as primary targets based on the quality information in Cadence regarding scope description, images, and status; these 12 projects represented ten different platforms. The other 15 projects had limited information, so they were classed as secondary targets.
    c. For the primary targets, the project leader's name was found and recorded in Cadence; this will be used to email the request.
4. For the longitudinal projects:

a. The list was filtered with the Approaching Gate column for a project classified as gates A and B, resulting in 26 projects.

b. The 26 projects were reviewed in detail in Cadence and ranked on the available descriptive information about the project. There were seven projects that the research tagged as a primary target based on the data in Cadence regarding scope description, images, and status; these seven projects represented six different platforms. The 19 other projects with little information were classed as secondary targets.

c. The nine primary target project leader names were found and recorded in Cadence; these will be used to email the request.

5. All 21 project leaders/managers were emailed with a standard request email.
6. For the retrospective case study, five positive responses from the primary list were received to be part of the research.
7. For the longitudinal case study, four positive responses from the primary list were received to be part of the research.

The case selection process described above resulted in nine cases. Table 4-2 shows a list of the nine case study projects and the organisational structure.

Table 4-2: MedDevCo Organisational Structure

Division	Business Unit	Research Strand	Case Study Number	Project Name
Surgical	Laparoscopic	Retrospective	2	Archway
Surgical	Visualisation	Retrospective	5	Minerva
Surgical	Lung Cancer	Longitudinal	6	Plexus
Surgical	Wound care	Longitudinal	8	Violet
Orthopaedic	Knee Reconstruction	Retrospective	1	Spark
Orthopaedic	Trauma	Retrospective	3	Barricade
Orthopaedic	Robotics – Knee	Retrospective	4	Amalgam

	Reconstruction			
Orthopaedic	Power Tools	Longitudinal	7	Stanley
Orthopaedic	Robotics - Shoulder Reconstruction	Longitudinal	9	Planetary

Source: Author

4.4.4.3 Generalisability

In qualitative research, generalizability in case study research refers to the extent to which the findings from a case study can be applied or extended to broader contexts or populations. This concept is crucial in qualitative research, where an in-depth examination of a specific instance, individual, group, or situation is often the focus (Yin, 2018). While case studies provide insights and rich data, their inherent specificity can raise questions about how broadly those insights apply. The key to enhancing generalizability in case studies is the case selection (Eisenhardt, 2021). Researchers often choose cases because they are typical, critical, unique, or revelatory, thus providing insights that are likely to apply in similar cases (Symon and Cassell, 2012). The depth and rigour of the case study also play a critical role. Detailed descriptions of the context and conditions allow readers to assess the relevance of their situations.

A purposive sample of innovation projects within a leading global medical device company was chosen to ensure the research yielded insightful results. This company was selected due to its reputation for innovation and broad customer base, including patients, surgeons, nurses, and hospital staff. Additionally, medical device companies tend to allocate a significant portion of their sales to research and development (Chatterji and Fabrizio, 2014). The researcher was granted access to confidential company information, facilitating the acquisition of comprehensive and valuable data.

The research did not rely on random case selection; instead, a deliberate approach was taken. The nine cases under study were carefully chosen based on their innovative nature and front end stage development. All cases were in the healthcare industry, specifically in the UK, Switzerland, and USA, and within the same organisation. This allowed for a more comprehensive analysis of the specific processes, training, and managerial decisions, which were similar across all cases. Furthermore, the data captured nuanced factors for the FEI, including the involvement of healthcare professionals.

Furthermore, while the research attempts to provide generalisable results and conclusions that can be applied to various cases and industries, this is challenging as the study has only focused on a single industry and company. To assess the extent to which the research can be generalised, four levels of generalisation can be considered: the company level, the medical device industry level, the level of product innovation, and the existence of country-specific disparities. These will be considered in the limitations of the research section in Chapter 11.

Qualitative methods may limit generalizability due to their small sample size. However, a cross-case analysis approach was implemented to combine the findings from each case. By utilising cases across various business units within a single organisation, outcomes can be deemed generalisable within the medical device industry, specifically for implantable medical devices.

4.4.5 Interview Participants Selection

To select the participants for the interview, the type of innovation projects in which they were involved was considered. Data was collected using semi-structured interviews with engineers, designers and marketers who were directly involved in the innovations (Sakellariou, Karantinou and Goffin, 2017); for an overview of the selected companies and participants, see Appendix L.

This number of cases resulted in four interviews for the pilot case study, 16 interviews for the four retrospective cases and 15 for the four longitudinal cases. This number of interviews was comparable to other studies relying on in-depth semi-structured interviews (Griffin *et al.*, 2009; Bohlmann *et al.*, 2013).

4.5 DATA COLLECTION SOURCES

Following on from sample selection, this section discusses the data collection source. The types and number of data collection sources "depend on the particular nature of the case study setting, of the subject being investigated and on data availability" (Goffin *et al.*, 2019, p. 595). Multiple data collection methods are typically used in case studies so that a broader understanding of the phenomenon can be observed, and triangulation is increased. Yin (2018) describes six methods of data collection – documentation, archival

records, interviews, direct observation, participant observation and physical artefacts; refer to Table 4-3.

Table 4-3: Six Sources of Data

Source of Evidence	Strengths	Weaknesses	Related to the Research	Mitigation of the Weaknesses
Documentation	Stable – can be reviewed repeatedly. Unobtrusive - not created because of the case study. Specific – can contain exact names, references, and details of an event. Broad coverage - long span of time, many events, and many settings.	Retrievability - can be difficult. Biased selectivity if collection is incomplete. Reporting bias. Access - may be deliberately withheld.	Understand what has been recorded and how information and data has flowed through the process.	Statement of confidentiality of the material. Request during the interview and follow-up emails.
Archival Records	Same as above for documentation. Precise and quantitative. Subject to post-event ration.	Same as above for documentation. Accessibility due to privacy reasons.	Same as above for documentation.	Same as above for documentation.
Interviews	Targeted - focuses directly on case study topics. Insightful - provides explanations as well as views.	Bias due to poorly articulated questions. Response bias. Inaccuracies due to poor recall. Reflexivity, e.g., Interviewee gives what interviewer wants to hear.	Semi-structed interviews to capture the participants understanding of the process.	For the retrospective study semi-structured and in-depth interviews will be used in conjunction with the CIT method to aide recall and reduce bias. For the longitudinal study semi-structured and in-depth interviews will be used and the period between occurrence of the event and interview time will be short.

Source of Evidence	Strengths	Weaknesses	Related to the Research	Mitigation of the Weaknesses
Direct Observations	Reality - covers events in real time. Contextual - covers context of event.	Time consuming. Selectivity - unless broad coverage. Reflexivity - actions may proceed differently because participants know they are being observed.	The research did not use direct observation in the workshop, as an insight may not occur in an observable environment.	Not applicable, this source of evidence will not be used in the research.
Participant Observation	Same as above for direct observations. Insightful into interpersonal behaviour and motives.	Same as above for direct observations. Bias due to investigator's manipulation of events.	The research did not use direct observation in the workshop, as an insight may not occur in an observable environment.	Not applicable, this source of evidence will not be used in the research.
Physical Artefacts	Insightful into cultural features. Insightful into technical operations.	Selectivity. Availability.	The research did not use physical artefacts, as an artefact may not be available at the time during the research.	Not applicable, this source of evidence will not be used in the research.

Source: Adapted from Yin, 2014, p. 114

4.5.1 Choice of Data Collection Sources

Reviewing the various data collection sources for case study research outlined in Table 4-3, the following have been considered. Firstly, observations may not work as a method, as customer insight may not occur during an observation period. An insight may be discovered hours, days or weeks after the market research data is analysed, so the case study research may not observe the insight occurring. Furthermore, even though the researcher had access to interview the team members and project documentation, observation of workshops was not permitted as teams consider their work to be confidential within the organisation. Therefore, observation as a data collection method was discounted for this research.

Interviews were conducted, and project documentation was made available; this is a valuable resource for a deep understanding of the phenomenon and provides a pathway

for data triangulation. Also, interviews are a crucial tool in data collection and form the primary data source. Therefore, a data collection methodology that employs interviewing and documentation was used in the research.

The following section will discuss the interview method in detail. As previously discussed in Section 2.4.6, the majority (17 of 19) of the empirical studies on customer needs and insight utilised a retrospective interview approach as their data collection method. Additionally, none of the 19 studies reports that they also utilised documentation or archival records to improve validity or enhance triangulation. This research used a retrospective and longitudinal approach combined with interviews and documentation. This resulted in nine case studies with 35 total participants. This approach enhanced the robustness of the findings compared to the previous 19 studies on customer needs and insights.

4.5.2 Consideration of Interviews

An interview is an interaction between the researcher and participant to gather data on the phenomenon of the study (Yin, 2018). The primary data source for the research was semi-structured interviews with individual participants, as this approach is a "highly efficient way to gather rich, empirical data, especially when the phenomenon of interest is highly episodic and infrequent" (Eisenhardt and Graebner, 2007, p. 28). The semi-structured interview used open-ended questions that allowed the researcher to "follow up on interesting and unexpected responses" (Wieneke and Lehrer, 2016, p. 253). In addition, Gioia, Corley and Hamilton (2012, p. 19) stated that "the semi-structured interview approach allows the researcher to understand both retrospective and real-time accounts by the people experiencing the phenomenon". Hence, the research used a semi-structured interview approach to collect the data for both the retrospective and longitudinal research strands. The interview attempted to understand how the customer insights were discovered – the life story of the customer insight, utilising a probe-learn-iterate approach to questioning (Brinkmann and Kvale, 2015).

The semi-structured interview process was selected because the discovery of customer insight is difficult to observe directly; this is due to it being a cognitive process. Also, it may not occur at a single time point when the researcher is present; many

anecdotes suggest that customer insight is a sudden inspiration in non-work environments. For instance, it may not occur during working hours but instead while taking a walk or even showering; obviously, it would not be possible to observe this.

The interviews were conducted in a virtual one-to-one setting using Microsoft Teams and lasted approximately 45 to 60 minutes. The participants were first introduced to customer needs and insight concepts and then asked to describe recent examples of where customer insights were discovered during an innovation project. The initial part of the interview contained general questions about the participant and their overall R&D experience, which assisted the interviewer in understanding the interview context.

The central part of the interview investigated the discovery of customer insight. Follow-up prompting questions may be asked: for instance, when did the customer insights occur? How did it happen? Where did this lead? Who else was involved? Etc. The interviewer only asked the follow-up questions after the participants had stopped giving the descriptive response.

4.5.3 Retrospective Case Study Data Collection

For the retrospective strand of the research, the *Critical Incident Technique* (CIT) (Flanagan, 1954) was utilised to gain a deep understanding of the discovery of customer insights during the semi-structured interview. This technique has been shown to be useful in inductive research (Gogan, McLaughin and Thomas, 2014; Bott and Tourish, 2016) and is sensitive to recall bias (Kraaijenbrink, 2012) and has been used when concepts are mainly intangible. CIT was first described by Flanagan (1954) as a qualitative research method which had its origins in the US Air Force in World War II for selecting and classifying new aircrew; since this point, it has been recognised as an effective exploratory and investigative tool, (Woolsey, 1996). The term *critical* refers to significant events in life, and these are defined as extreme behaviour, such as discovering customer insights. Therefore, this critical incident can be more accurately identified and described than everyday behaviours (Flanagan, 1954). Incident refers to an "observable human activity that is sufficiently complete to permit inferences and predictions" (Flanagan, 1954, p. 327). The use of CIT for interviews has not been reported in the previous product

innovation empirical studies (refer to Section 2.4.6) on customer needs and insights; therefore, it presented an opportunity to extend its use in this field.

4.5.3.1 Interview Guide for the Retrospective Case Study

A set of interview questions based on CIT techniques were developed to guide the interview. The interview guide was created based on the literature findings and then revised based on a pilot study (Gioia, Corley and Hamilton, 2012). The design of the interview guide for the retrospective case study (Appendix B.3) has five sections:

- Preamble points
- Participant demographics
- Introduction of customer needs and insights (if required)
- Customer insight questions
- Closing questions

4.5.4 Longitudinal Case Study Data Collection

A longitudinal case study is the 'study of change repeated measures over time from the same unit of observation' is crucial (Ployhart and Vandenberg, 2009, p. 97) p 97. For the longitudinal strand of the research, CIT was not used; semi-structured interviews were used and followed the interview guide in Appendix B.4. The longitudinal research followed the innovation projects over about a 10-month period, during which time the teams advanced through the front end. For each case, three points in time for interviews were used; this allowed data to be collected as the same team advanced through the front end and time-bound the data collection. This follows (Ployhart and Vandenberg, 2009) advice the minimum number of repeated measures is three. This approach to data collection assisted in seeing how the market research changes over time into customer needs and insights. It will also provide findings to understand the relationship between needs and insights. FEI.

4.5.4.1 Interview Guide for the Longitudinal Case Study

The design of the interview guide for the longitudinal case study guide (Appendix B.4 and B.5) has five sections; they are:

- Preamble points,
- Participant demographics,
- Introduction of customer needs and insights (if required),
- Customer insight questions,
- Closing questions.

4.5.5 Documentation Data Source

The project-related documents were analysed for the retrospective and longitudinal research strands and were examined as they were made available throughout the process. Documents that were collected for this research are:

- Design requirement specifications – these are typically a list of customer needs and insights.
- Market analysis and product positioning (target product profile document) – a broad description of the product capabilities, intended user and market. They may also contain market research data.
- Presentations.
- Company operating procedures.

4.6 DATA ANALYSIS

Data analysis is aimed at generating theory (Frishammar *et al.*, 2016; Beverland, Micheli and Farrelly, 2016; Stigliani and Ravasi, 2012). The analysis was an iterative coding process whereby the data was revisited as structures from each case emerged. The interviews and the analysis proceeded in tandem (Gioia, Corley and Hamilton, 2012). For this type of inductive research, individual cases were initially analysed and then compared across the retrospective and longitudinal cases to construct a conceptual framework; refer to Table 4-4 for a cross reference of the RQ, the data collection source, and the analysis method.

NVivo Release 1.0 software (QSR International, 2022) was used to analyse the qualitative data. The transcripts from the semi-structured interviews and the

documentation were analysed to find emerging themes (Symon and Cassell, 2012). The researcher was not "constrained by prior theory and instead saw the development of relevant theories, hypotheses, and concepts" (Pare, 2004, p. 239). A case study database was developed in NVivo to store the raw data, as suggested by Yin (2018). The database contains interview transcripts, case study interview notes, and case study documents.

Table 4-4: RQ, Data and Analysis Cross-Reference

Research Question	Data Used	Analysis	Research Method
RQ 1) How are customer needs related to customer insights in the work of innovation teams at the front end of innovation?	Interviews	Thematic Coding	Retrospective multi-case study.
RQ 2) How does the process of discovering customer insights unfold within innovation teams?	Interviews Documents	Thematic Coding	Retrospective multi-case study.
	Interviews Documents	Thematic Coding	Longitudinal multi-case study. Time windows for 3 interviews

Source: Author

An SLR provisional coding list (Appendix B.1) was generated from the SLR before the data collection stage. This provided a foundation before starting the coding process. The literature identified 19 relevant codes to describe customer needs and customer insights. Emerging codes were added during the data analysis process.

4.6.1 General Coding Approach

First-order concept coding of the interview transcripts was conducted. A coding frame emerged during the first-order coding. NVivo Release 1.0 software (QSR International, 2022) was used for the coding. The first-order concept coding method, as recommended by Saldana (2016, p. 73), was:

- Attribute coding - a basic description of the information, such as participant attributes and demographics.

- Descriptive coding – a summary "in a word or short phrase – most often a noun – the basic topic of a passage" (Saldana, 2016, p. 102).
- In vivo - captures words, language and terms used by the participants.
- Process coding - looks for gerunds in the data (-ing words) to find the participants' actions.

The pilot study also used structural coding, which is a contextual phrase that relates to the RQ and breaks down the data to allow quick access to key passages. However, this did not provide any additional value to the analysis, so it was abandoned as a coding method for the subsequent case studies.

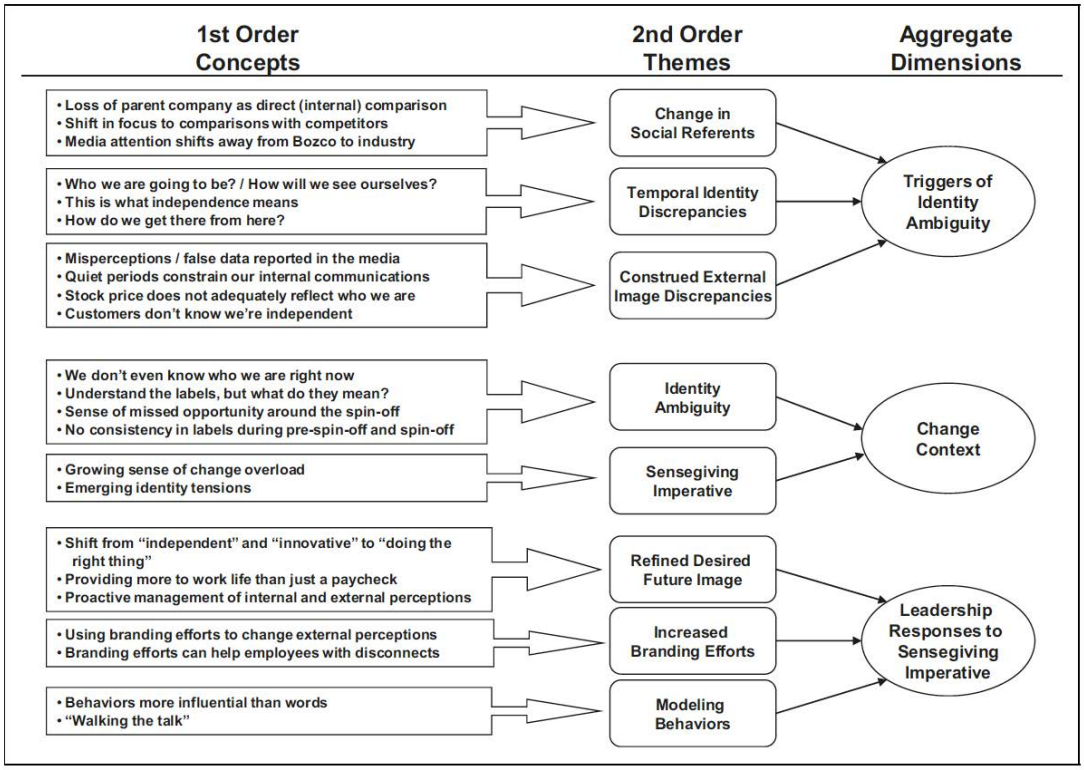
Second-order theme coding identified the emerging themes from the first-order coding. The Gioia, Corley and Hamilton (2012, p. 18) method was utilised to deliver a "systematic presentation of both a first-order analysis and a second-order analysis", providing a "qualitatively rigorous demonstration of the links between the data and the induction of the new concept". The Gioia, Corley and Hamilton (2012, p. 20) method stated the following:

1. Generation of the first-order codes is where the researcher can become overwhelmed, but it is at the point at which the researcher must persevere with the data.
2. Similarities and differences develop into second-order themes, which reduce the codes; this step is referred to by Saldana (2016) as *Eclectic coding*, i.e. coding that captures a compatible combination of two or more first-order codes to synthesise the number of codes into a unified scheme.
3. If necessary, the second-order themes are distilled into aggregate dimensions whereby a data structure is built. A data structure is the graphical representation of the data, demonstrating rigour in qualitative research. Refer to Figure 4-3 for an example of a data structure (Gioia, Corley and Hamilton, 2012, p. 21).

, and Hamilton (2012) stated two disadvantages to their method. Firstly, researchers force-fit the first- and second-order conceptualisation into the research without considering the methodological approach, which may decrease the flexibility and benefit of the study. Secondly, the method is used as a template, reproducing the exact format of

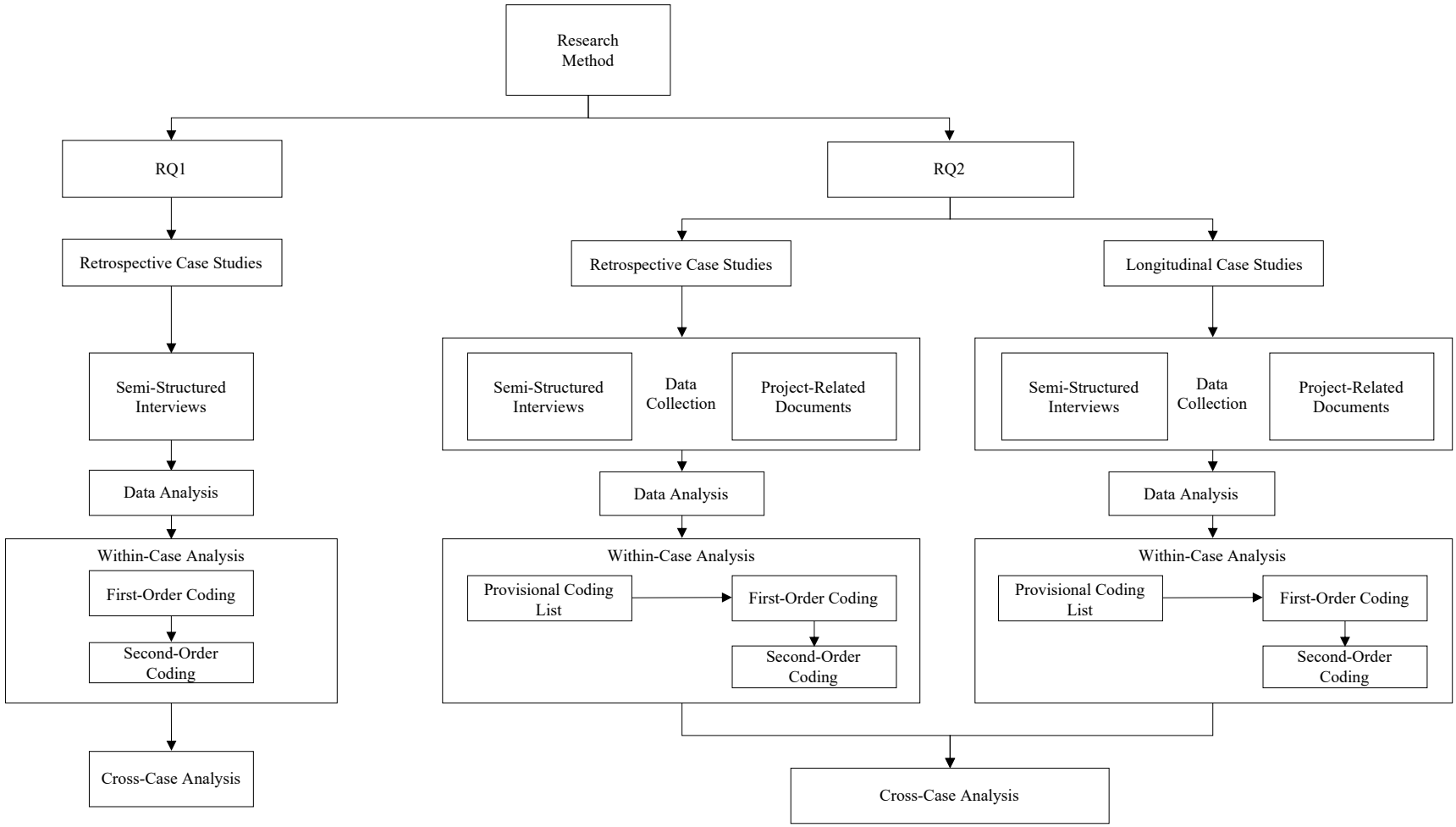
the data structure in other published papers. The research mitigated these disadvantages by ensuring that the second-order coding was emergent and only based on the first-order coding and applying the Saldana (2016) method to the first-order coding. To improve validity and reliability, two aspects were considered when combining the Saldana (2016) and Gioia, Corley and Hamilton (2012) methods: firstly, using the systematic approach suggested by Saldana (2016) for coding the first-order codes, as Gioia, Corley and Hamilton (2012) did not indicate any specific approach to first-order coding; secondly, in certain conditions, a first-order code may belong to more than one second-order code. Gioia, Corley and Hamilton (2012) reported that each first-order code should only belong to a single second-order code. Therefore, to resolve this (where a first-order code belongs to more than one second-order code), the first code was coded more than once and attributed to the appropriate second-order codes.

Figure 4-3: Coding Method



Source: Adapted from Gioia, Corley, and Hamilton, 2012, p. 21

Figure 4-4: Research Method Process Flow



Source: Author

4.6.1.1 Retrospective Data Analysis

The pilot study and the retrospective cases followed the same analysis process. This section will outline the analysis steps for RQ 1 and RQ 2.

For RQ 1, the analysis steps were:

1. First-order coding of the descriptions of the participant's understanding of needs and insights and descriptions of the participant's feedback of needs and insights definitions and relationships from the SLR.
2. Second-order coding to aggregate these into a broader understanding.

The retrospective first and second data coding for each case study followed the process described in Section 4.6.1. In addition, for RQ 2, the analysis steps were:

1. The second-order codes are arranged into the FEI process order to find the process steps and the inputs, actions, and outputs for each of the five process steps. A full description of the process was also provided.
2. Using the second-order codes, a process overview for each case was produced. The first-order and second-order coding structure is shown with representative quotes in an appendix for each case study; this step increased validity.
3. Finally, a framework that combined the process steps, inputs, actions and outputs was developed for each case. The process steps, input, action and output with representative quotes are shown in an appendix.

As the theory emerged, the process steps from the previous case study analysis were used to inform the analysis of the following case study. Standard coding terms aided the cross-case analysis (the cross-case analysis process will be discussed in Section 4.6.3).

4.6.1.2 Longitudinal Data Analysis

As the longitudinal data collection differed from the retrospective data, the data analysis differed. For the initial interview and document collection, the first and second data coding for each of the case studies followed the process described in Section 4.6.1. The second and third interviews used emergent codes to understand the changes and new

process steps from the previous interview. This change of data over time produced a full picture of the FEI process that the case study underwent.

Capturing the longitudinally of the case studies is critical. Therefore, the process that was uncovered from the analysis was captured in time periods. The data that was collected included the work that was completed and in process prior to the interview, as well as planned activities that were going to be done. Each process step was highlighted with a timeframe; this allowed a better understanding of the order of the steps and any iterations or looping-back. As such, to address RQ 2:

1. The second-order codes are arranged into the FEI process order to find the process steps and the inputs, actions, and outputs for each of the five process steps. A full description of the process is also provided.
2. Using the second-order codes, a process overview for each case was produced. The first-order and second-order coding structure is shown with representative quotes in an appendix for each of the case studies; this step increases validity.
3. Finally, a framework that combined the process steps, inputs, actions and outputs was developed for each case. The process steps, input, action and output with representative quotes are shown in an appendix.

4.6.1.3 Cross-Case Data Analysis

The following section will describe the retrospective and longitudinal cross-case analysis (Chapter 10). The cross-case analysis of nine case studies was compared to two existing FEI processes, the New Concept Development (NCD) model (Koen *et al.*, 2001) and the New Product Development Front End (NPDFE) model (Khurana and Rosenthal, 1997). This comparison identified how the elements from the research related to the elements in these two models. Incorporating the longitudinal time frame data that shows the order of the process steps further validated the framework. The next step in the analysis was the identification of the inputs, practices and outputs across the cases.

The inputs, practices and outputs across the cases will be tabulated, and their occurrences in each case will be counted. The use of quantitative data (in this case, simple counting) in a qualitative study assisted in providing further validity to the claims in the cross-case analysis. Maxwell (2010, p. 478) stated, “Numbers in the sense of simple

counts of things are a legitimate and important sort of data for qualitative researchers". The simple count of instances also demonstrates that the number of cases in the study was reaching theoretical saturation. Maxwell stated that 'integrating According to (Hannah and Lautsch, 2010), this type of count is referred to as credential counting. As such, the counting does not replace the descriptive evidence. It provides a supplement to the conclusions (Maxwell, 2010).

4.7 VALIDITY AND RELIABILITY CONSIDERATION

To ensure the quality of the research, *construct validity, internal validity, external validity,* and *reliability* are key considerations when undertaking case study research. (Gibbert and Ruigrok, 2010; Goffin *et al.*, 2019). In general, validity mitigates the risk of flawed findings, and reliability considers whether a different researcher would reach the same results given the same data. The interrelationships of the three validations (construct, internal, external) are not independent but build on each other. It has been suggested that internal and construct validity are prioritised over external validation (Gibbert and Ruigrok, 2010). For construct validity, a clear protocol is required before the research commences; in this case, the research methodology was established, which includes the interview guides (Appendix B) and data collection plan (Section 4.4.4 and 4.4.5). Then, an explanation of how the plan differed from the actual data collection process is required (i.e., organisation access, time frame, interviewee selection). For this research, for the actual data that was collected, refer to Appendix L. For internal validity, the research should have an "offensive strategy" to justify case selection and analysis, whereas, for external validity, a "defensive strategy is used to explain that generalisability is limited in the research" (Gibbert and Ruigrok, 2010, pp. 728-729). For the case selection justification, refer to Section 4.4. and for the data analysis justification, refer to Section 4.6

For qualitative research, both triangulation and a clear explanation of the data collection (construct validity) and analysis (internal validity) process are required to improve the validity (Eisenhardt and Graebner, 2007; Yin, 2018). Consequently, the interviews were transcribed, coded, and analysed to draw inferences from the interviews and documentation. See Table 4-5 for a summary of the quality considerations for the research method and the measures taken to improve validity and reliability.

Finally, the data will not be coded by another research, as such inter-coder will not be performed to improve the reliability of the findings. A single coder, the PhD researcher, will perform the coding. It is acknowledged this is a limitation of the research.

Table 4-5: Validity and Reliability Considerations

Quality Test	**Description**	**Case Study Measures that were Taken**
Construct validity	The correct operational measures are used for the concepts. A study investigates what it claims to investigate and leads to an accurate observation of reality.	Triangulation - Use multiple data sources from multiple cases to look at different angle of the same phenomenon. Interview to review the transcript and preliminary analysis. Research plan - Chain of evidence from RQ to conclusion.
Internal validity	The correct conclusions are reached. Causal relationships between variables and results.	Use multiple case. Use multiple data sources for triangulation. Provide rich description in the results and conclusions. Clearly explain the data collection and analysis process.
External validity	Lack of generalisability across other settings. Analytical generalisation from empirical observations to theory.	Use literature and theory throughout the analysis to generalise. Cross-case analysis.
Reliability	The research can be replicated with the same results. Absence of random error.	Maintain transcripts and interviews. Use detailed case protocols and explain the analysis process. Transparency and replication – careful documentation to facilitate retrieval (database, software, preliminary conclusions.

Source: Adapted from Yin, 2018 and, Gibbert and Ruigrok, 2010

4.8 FEASIBILITY STUDY AND PILOT CASE STUDY

Two studies were undertaken to test the research design: a feasibility study and a pilot case study.

4.8.1 Feasibility Study Design

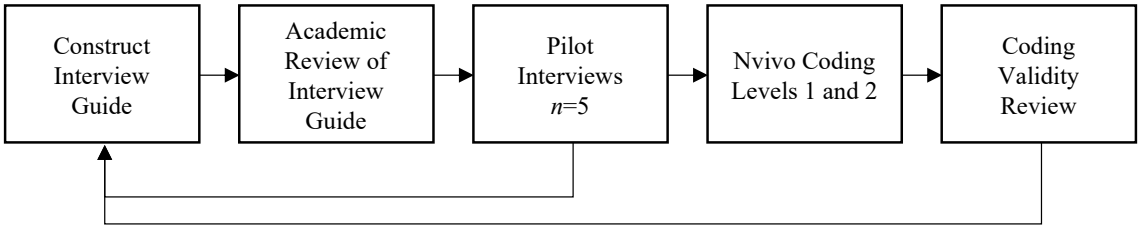
The feasibility study served two purposes: firstly, to determine whether the required data to answer the RQs could be obtained via semi-structured interviews, and secondly, to allow for the evaluation and improvement of the research design and retrospective interview guide. The study was a preliminary investigation that took place prior to the pilot retrospective case study, and the results can be found in Chapter 5. It's important to note that the feasibility study focused on participants who had worked on previous innovation projects rather than on the same project. This approach was taken to assess whether participants could recall the discovery of customer insights, which was crucial to ensuring the feasibility of the primary research and research design. The selection criteria for the participants were that they have worked on a product innovation project and had worked in various product development or innovation projects in their careers. This study only used interviews as a data collection method. The interview data was coded in the same manner as stated in Section 4.6.

4.8.2 Pilot Study Design

The pilot case study was the next step after the feasibility study. It evaluated both the research design interview guide and the documentation. A pilot study has been reported as a critical step before the main study, as it provides an opportunity to improve the research design, data collection plan and interview guide (Goffin *et al.*, 2019). This approach for testing both the retrospective and longitudinal research strands was undertaken as the two questionnaires are similar and did not require a separate pilot study for the longitudinal approach. The pilot study was also used to test the data collection method and the data analysis coding process within a single case; refer Figure 4-5: Pilot Study Process for the pilot study process. Refer to Chapter 6 for the pilot case study results.

The pilot study interviewed five participants involved in the same innovation project regarding their experience with customer needs and insights on an innovation project. The interview guide was used to assist the interviewer. Interview transcripts and documents were used for data coding at the analysis stage. The selection of the participants for the pilot study was the same for the main study.

Figure 4-5: Pilot Study Process



Source: Author

4.9 CASET ASSESSMENT

The CASET assessment was performed on the empirical qualitative studies; refer to Table 2-4 for the results. The average score was 5.95 for the empirical studies; one paper (Hargadon and Bechky, 2006) also scored 9, dropping a point for not stating a pilot study was conducted. The same evaluation was performed on this research and found that the methodology scored 8 out of 10 (Goffin *et al.*, 2019). Two points were dropped on was the questions for 'review and validation of data' and 'inter-coder agreement'; this research is for a PhD, thus there is not an additional researcher involved that could perform the coding. The results from the CASET evaluation are shown below in Table 4-6.

Table 4-6: CASET Assessment

	Evaluation Criteria	Evaluation Question	Score (0/1)	Objective Evidence
Research Design	*Theoretical foundation*	Was a clear explanation given of why the case method was the most appropriate method to adopt?	1	Section 4.2
	Pilot study	Was there a pilot study preceding the main study?	1	Section 4.8
	Theoretical sampling	Was an explanation provided of which case(s) were chosen and why?	1	Section 4.4.1
Data Collection	*Triangulation*	Was the research based on multiple sources of data?	1	Section 4.5
	Review and validation of data	Was case study evidence reviewed and validated by external parties?	0	None
	Transparency of data collection	Was it made clear how the data collection process was conducted?	1	Section 4.5
Post-Hoc	*Inter-coder agreement*	Was the data coded by multiple investigators?	0	None
	Case presentation	Were findings and empirical evidence presented in a way that made it clear how the author(s) reached their conclusions?	1	Chapter 6, 7, 8, 9
	Case interpretation	Did the case analysis move beyond description and conceptual ordering?	1	Chapter 10
	Reflecting on validity and reliability	Was there a discussion about the quality of the research?	1	Chapter 11
	Overall quality score (out of 10)		**8**	

Source: Adapted from Goffin *et al.,* (2019)

4.10 SUMMARY OF THE RESEARCH METHODOLOGY CHAPTER

The UoA is the process of discovery of customer insights within the FEI and is based on the RQs. The multi-case research had two strands to collect data that provided data from two perspectives: a retrospective and a longitudinal case study approach. Firstly, the retrospective case studies gave the historical view of innovation projects and allowed the researcher to dig deep into discovering customer insights. Secondly, the longitudinal case study provided the opportunity to explore how customer insight developed during the FEI.

The multiple case samples were chosen based on the selection criteria, which included the project being an in-house development, the product innovation being sufficiently radical, and access to conduct the research being granted. One project was

selected for the pilot study, four for the retrospective study, and four for the longitudinal study. A single medical device company was used for all the case studies. Once the projects were chosen, the innovation team members, including the R&D and marketing functions, were contacted.

The data from the case studies consisted of two formats: transcripts from semi-structured interviews and project documentation. The retrospective study consisted of a single interview with each innovation team member, with 16 interviews in total across the four projects. The longitudinal cases consisted of three interviews with each team member for ten months and 41 interviews with 15 people.

The data was analysed using Saldana's (2016) first-order and second-order coding method and the Gioia, Corley and Hamilton (2012) theory-building approach. The first order involved attributed, descriptive, in vivo and process coding. The second-order coding identified the emerging themes.

To ensure the quality of the research, construct validity, internal validity, external validity, and reliability measures were undertaken, including triangulation, interview guides and a pilot study. In addition, a cross-case analysis approach was used to aggregate the findings from each case, thus supporting generalisability.

Chapter 3 discussed the research design, and Chapter 4 built on the design with the proposed research method for the study. The next chapter (Chapter 5) will discuss the feasibility case study, which was undertaken to verify the possibility of finding the data to answer the RQs via a semi-structured interview and to determine the likelihood of success. The pilot case study then follows this in Chapter 6.

CHAPTER 5 FEASIBILITY CASE STUDY

5.1 INTRODUCTION

Chapter 5 discusses the feasibility study. This feasibility case study was undertaken to verify the possibility of finding the data to answer the RQs via a semi-structured interview to determine the likelihood of success. This included participants being able to recall and discuss the customer needs and the insight process they have experienced. It also provided an opportunity to evaluate and improve the research design, data collection plan and the retrospective interview guide and to practise data collection. The lessons learned from the study were fed a revised research design. The feasibility study was a preliminary investigation prior to the pilot retrospective case study, which is reported in Chapter 6. As such, it only used semi-structured interviews to collect data.

This chapter includes the following sections:

- Background to the feasibility study
- Data collection
- Data analysis
- Relationship of customer needs to customer insights
- The insight discovery process
- Preliminary conclusions
- Reflections on the feasibility study
- Summary of the feasibility study chapter

5.2 BACKGROUND TO THE FEASIBILITY STUDY

The feasibility study was based on a division of a multinational healthcare company that produces pharmaceuticals and medical technology. The study involves a subsidiary business unit (referred to as Thackeray) that specialises in developing and marketing joint reconstruction (hip and knee) medical devices. The marketing and R&D functions are in both the UK and the USA. The business unit is one of the top three in their market.

This business unit was selected as the researcher had existing contacts, which aided timely access, and the participants were actively working with customers to develop new products. Access to the interviewees within the business unit was achieved by contacting them through the company email system. If the interviewees agreed that they had the time and confirmed they had experience with an innovative project, a one-hour meeting was set up in their calendars. Consent to be interviewed and confidentially was agreed on for the interview.

5.3 DATA COLLECTION

Data collection at Thackeray took place over a three-week period. Six semi-structured interviews were scheduled in each interviewee's Outlook calendar. The researcher used his company email address for all communications to facilitate access and response. The interviewees covered both marketing and R&D functions, and all have been involved in NPD, specifically in the front end phase. Table 5-1 shows the details of the participant's roles and responsibilities, interview duration, date, and number of transcript pages. The total duration of the interviews was 4.5 hours, resulting in 74 pages of transcripts.

Table 5-1: Data Collected for Thackeray

Interview Number	Role and Responsibility	Interview Reference	Experience in NPD	Date	Duration (mins.secs)	Transcript (no. of pages)
1	Principal Engineer	TH1-I1	16 years	25th May 2021	4843	12
2	Principal Engineer	TH1-I2	15 years	26th May 2021	45.36	13
3	Marketing Director	TH1-I3	26 years	8th June 2021	34.12	11
4	Principal Engineer	TH1-I4	16 years	2nd June 2021	50.12	13
5	Principal Engineer	TH1-I5	20 years	10th June 2021	38.41	11
6	Marketing Director	TH1-I6	20 years	10th June 2021	46.31	14
				Totals	262.75	74

Source: Author

Microsoft Teams was used for each of the one-to-one virtual interviews, and the six interviews lasted on average 44 minutes. The interviews were recorded with the cameras

turned on using the Microsoft Teams recording function. As the interviewees were well known to the researcher, formal introductions were optional; however, in the main case studies, a more formal introduction was done. The first two minutes were spent explaining the research and the interview process. After this, the interviewee described their current role and experience. The remaining time was used for the semi-structured interview utilising the retrospective interview guide. The interview recordings were transcribed using the auto-transcription service Otter.ai. After the auto-transcription process was completed, the researcher proofed the transcript by listening to the recording and changing any transcription errors.

5.4 DATA ANALYSIS

5.4.1 First-Order Coding

The following steps were undertaken for the first-order coding. In the first step, the six PDF format interview transcripts were uploaded into NVivo for coding the SLR provisional coding list (refer to Appendix B.1), which was recreated in NVivo. In the second step, the interviewee attributes were coded. Descriptive coding was the next step; it summarised sections (sentences or paragraphs) with a short word or phrase. This is when the general provision coding list was used. If a provisional code did not best describe the coded section, then an emergent code was created. The next step looked for specific words (in-vivo and process coding). These were again coded either by using the provisional codes or by creating emergent codes; refer to Section 4.6 for a detailed explanation of the coding process. The first-order coding phase produced 62 codes in total;19 provisional codes were used, and 43 emergent codes were created. The coding resulted in 383 references across the six transcripts. A complete list of the first-order and second-order codes and associate reference quantities can be found in Table 5-2 and Table 5-3, respectively. The coding source (SLR provisional or emergent) has also been stated.

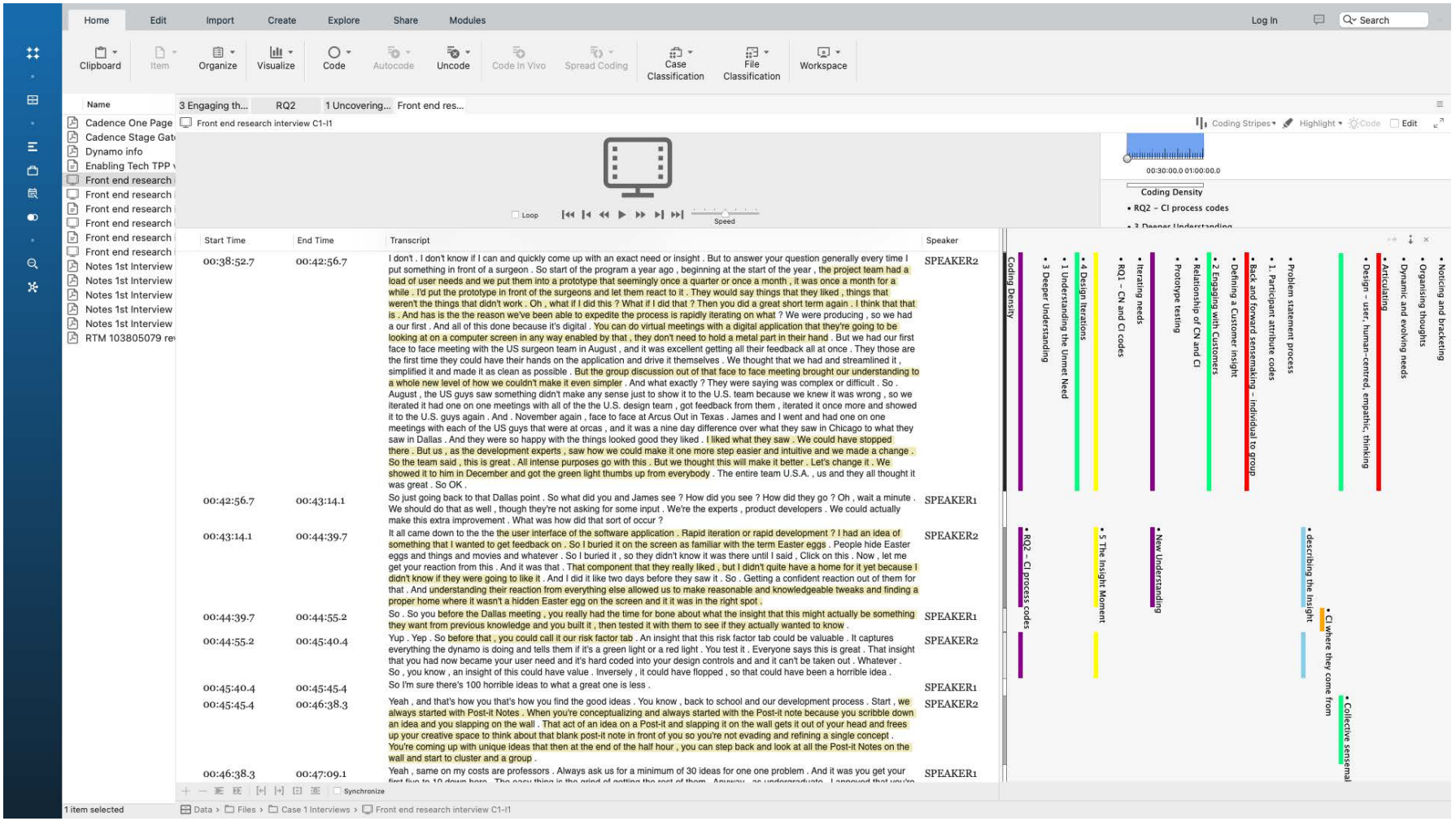
For example, Figure 5-1 shows a section of the interview transcript with the principal engineer, showing the first-order codes. The yellow highlighted transcript with the associated codes is shown as coloured coding stripes. An example is the ‘New understanding’ first coder code, which coded the statement, “*Group discussion out of that face-to-face meeting brought our understanding to a whole new level of how we couldn't*

make it even simpler". This coding was used to define second-order coding, which is described in the next section.

5.4.2 Second-Order Theme Coding

The second-order coding analysis involved combining two or more first-order codes to synthesise the codes into themes. For example, the second-order code 'Needs and Insight Process' was synthesised from the following 14 first-order codes, e.g., aha moments, Future thinking, problem-solving, happened over time, etc. These emerging themes began to suggest concepts that try to answer the RQs. The consolidation of the first-order codes resulted in five second-order themes. Figure 5 2 shows examples of the first-order codes and the second-order themes for RQ 1 and RQ 2.

Figure 5-1: NVivo Screenshot of First-Order Codes



Source: Author

Table 5-2: First- and Second-Order Coding for RQ 1

1st Order Codes	Code Source	No of Codes	2nd Order Codes	No of Aggregated Codes
Actionable non obvious insight	Emergent	7	Understanding the Relationship of Customer Needs and Insights	173
Benefits and value	SLR Provisional Code	14		
Cant be solved	Emergent	2		
Customer definition	Emergent	2		
Deep understanding of underlying motivations	SLR Provisional Code	5		
Defining a Need	Emergent	40		
Insight definition	Emergent	40		
Insight helps understand of the product use	Emergent	2		
Insight not a qualitative need	Emergent	2		
Kano - Delighter	Emergent	10		
Relationship of insights to needs	Emergent	10		
Solutions to needs	Emergent	3		
Synonymous user and customer need	Emergent	1		
Technology solution and technical language	SLR Provisional Code	10		
Unarticulated, tacit, latent, unconscious	SLR Provisional Code	17		
Understanding an Insight	Emergent	0		
User needs are referred to	Emergent	3		
User needs as an outcome	Emergent	2		
User needs into engineering specs	Emergent	1		
Voice of the customer is our role	Emergent	2		

Table 5-3: First- and Second-Order Coding for RQ 2

1st Order Codes	Code Source	No of Codes	2nd Order Codes	No of Aggregate Codes
Customer involvement	SLR Provisional Code	3	Uncovering Customer Needs	36
Dynamic and evolving needs	SLR Provisional Code	2		
Finding the value in customer needs	Emergent	1		
Identifying needs	SLR Provisional Code	15		
IP considerations	Emergent	3		
Insight meeting	Emergent	6		
Listening to the Customer	SLR Provisional Code	2		
Market research	SLR Provisional Code	0		
Own words	SLR Provisional Code	0		
Source of the need	Emergent	5		
Using analogue products	Emergent	5		
VOC	SLR Provisional Code	6		
Creativity and imaginative thinking	SLR Provisional Code	0	Techniques Used to Discover Insights	64
Customer knowledge	Emergent	3		
Design - user, human centred, empathic, thinking	SLR Provisional Code	0		
Developing the insight	Emergent	16		
Development time to address insight	Emergent	1		

1st Order Codes	Code Source	No of Codes	2nd Order Codes	No of Aggregate Codes
Effort required to identify customer needs and customer insights	Emergent	1		
Ethnography and observation	SLR Provisional Code	13		
Gestalt	SLR Provisional Code	0		
Identifying and generating insights	SLR Provisional Code	0		
Market Orientation	SLR Provisional Code	0		
Outcome driven innovation model	Emergent	2		
Transforming data into meaningful knowledge	SLR Provisional Code	4		
Workarounds	Emergent	1		
Working through the process	Emergent	23		
Aha moments	Emergent	7	Customer Needs and Insight Process	103
Confirming the insight finding	Emergent	5		
Future thinking	Emergent	4		
Happened over time	Emergent	3		
Identifying the problem	Emergent	8		
Insight generation participants	Emergent	16		
Overcoming design challenges	Emergent	2		
Problem solving	Emergent	5		
Radical, incremental innovation	SLR Provisional Code	5		
Realising the customer problem	Emergent	12		

1st Order Codes	Code Source	No of Codes	2nd Order Codes	No of Aggregate Codes
Solution testing	Emergent	2		
Solution thinking	Emergent	10		
Understanding the possibilities	Emergent	7		
Understanding the problem	Emergent	11		
Emotional Response to Discovering an Insight	Emergent	7	Emotional Response to Discovering Customer Insights	7
			Total RQ 2 codes	222

Source: Author

5.5 RQ 1: RELATIONSHIP OF CUSTOMER NEEDS TO CUSTOMER INSIGHTS

This section addresses RQ 1: How are customer needs related to customer insights in practice in the work of innovation teams at the front end of innovation? This RQ was answered based on data from six interviews with members of the Thackeray project.

5.5.1 Understanding Customer Needs

To understand the process for uncovering customer needs, the first step was asking the interviewees their impression of the customer need definition from the SLR (Chapter 2). A PowerPoint presentation was used to show the definitions to the interviewees; refer to Appendix B.6. The interviewees stated that they typically used the terms 'user need' or 'customer requirement' instead of customer need. It was confirmed that these terms are synonymous or used interchangeably when discussing customer needs, "We *tend to talk about user needs or customer requirements*" (TH1-I1). Additionally, the VOC was also used in the context of customer needs as a verb relating to the process of gathering needs. It was recognised that customer needs were referred to as having a qualitative aspect, which in turn are then translated into quantitative engineering specifications that are used in the NPD process; "*A user need is a qualitative requirement that we need to fulfil for the user to be able to perform a task. And so, we take those qualitative requirements and turn those into engineering specifications that we would call design inputs within our* process" (THI-I1).

The respondents understood the term customer as the direct user (such as the surgeon and operating staff). However, it was acknowledged that needs could also come from other types of customers; for instance, "*I think you can generate needs from almost every landscape that we have access and experience"* (THI-I4). It was found that the participants think of customer needs as things that the customer verbally tells the team. Terms such as *verbatim* or *explicitly stated* were used, *"I think it's generally something that comes almost verbatim from the customer, be that the surgeon, be the perioperative staff, the cleaning staff or whatever the people that you're developing the product for, and it's something that they desire or wants to see in the product."* (THI-I5). However, there

was agreement that the team crafts a customer's need. As such, a translation of the customer's verbatim statement is inferred. The principal engineer stated, *"the crafting of the customer need is an exercise to elucidate the future benefit and value of the products used"* (THI-I4).

In discussing the articulated and unarticulated customer needs, a Principal Engineer compared the problem to the ability to use a similar product to elicit new needs. He stated:

> *"Sometimes they know what that is, and sometimes they don't, because if they think to know when you need something, you have to have experience of it. So, if you're developing a new technology or product, and there's not an analogue for it that the customer is already familiar with, sometimes it's more difficult to draw out those needs because you don't know what you don't know. But generally, if you're doing a product that is an incremental innovation, or some sort like that, there's a predicate that they can base their assessment on, and then a list of needs and wants for that product. However, evaluating their needs with the future benefits or value the product could offer is challenging if customers do not have an analogue to compare against." (THI-I5).*

When considering the customer need definition, the 'value and future benefit' terms within the definition were questioned. The respondents stated that the customer does not speak of benefit and value, only performance. Customers may not understand the value the product could offer them now. The Marketing Director (THI-I6) mentioned the term 'value proposition'. He stated, *"that statement is more for me something closer to a value proposition than a customer need"*, explaining that the company's value proposition is "*what the company is going to do about it"* (THI-I6).

In contrast, the Principal Engineer (THI-I4) agreed that the future should be considered, as it is recognised that throughout an innovation project, the ecosystem in which the needs belong may change, which causes the team to revisit the established needs. As stated by the Marketing Director (TH1-I3), the team needs to convey the value and benefit and not look to the customers to provide this directly: *"Surgeons didn't actually believe that they needed that. So, they would not have had a value in that. We recognise that, that they, we believed that there would be a value, so we went ahead and*

created it. Once surgeons got it in their hands, they were like, 'yeah, we do really value this product aspect'" (TH1-I3).

Breaking down the customer need definition into its constituent parts assisted with clarification for the interviewee's understanding and interpretation; refer to Appendix B.6 for the presentation with the broken-down definitions that were shown to the participants during the interview. The participants agreed with the definition. It aligned both with their current practices and with the findings in the SLR, except for the future benefit and value part. The participants could describe a customer need in their own words. Refer to Table 5-4 for representative quotes from the participants.

Table 5-4: Evidence of Understanding Customer Needs

Theme	Representative Quotations
Understanding Customer Needs	*A user need is a qualitative requirement; we take those qualitative requirements and turn those into engineering specifications. We talked about the voice of the customer.* (TH1-I1)
	I accept that users don't articulate an awful lot of their needs. (TH1-I2)
	Surgeons didn't actually believe that they needed that. So, they would not have had a value in that. We recognise that, that they, we believed that there would be a value so that we went ahead and created it. Once surgeons got it in their hands they are like, 'yeah, we do really value this product aspect'. (TH1-I3)
	A user need is a statement from the user, the customer that details what they need in a product by either feature or performance for that product to be successful, or to, to do the perform the function it is intended to perform. (TH1-I4)
	If the product is entirely new it becomes more difficult for the customer to indicate what the future benefit would be, because you don't have an analogue to what that benefit could be. (TH1-I5)
	Always talk about the unmet need; GSM, we're looking for the unmet needs. The value proposition is, is one step further, it's where you then take, you take the customer need, and you frame it with, you know, with what you're going to do about it. (TH1-I6)

Source: Author

5.5.2 Understanding Customer Insights

After discussing customer needs, the next element in understanding the relationship between needs and insight was to review the definition of customer insights; refer to Appendix B.6 for the definition shown to the participants during the interview. Therefore, the following section considered each participant's understanding of customer insights.

The six participants responded in their own words; examples are shown in Table 5-5. At the start of the interview, the interviewees explained their understanding of

customer insights. For instance, the Principal Engineer (TH1-I2) explained that insights are challenging to obtain but, once discovered, can provide an opportunity to delight and, if addressed, give the product a *"disproportionate benefit"*. It was reported that gaining this deep knowledge cannot be obtained by a 10-minute conversation but is built up over time by learning the subject matter and interacting with the customer. This led to the recognition of differentiating customer needs from insights, as needs are described as essential aspects of the product, whereas insights are product benefits. A Principal Engineer (TH1-I5) stated that needs are translated from a qualitative statement into engineering specifications. Still, insights are a deep understanding of the product's use and cannot be translated into engineering specifications.

One Marketing Director stated that insights are a problem the company still needs to be made aware of. He explained the term unmet needs is used interchangeably with customer insights and that marketing is looking to uncover unmet needs, describing an unmet need as *"what is going on in the market that we know is an issue, and that there isn't a true solution to that thing"* (TH1-I3). The other Marketing Director (TH1-I6) added:

> *"We always talk about the unmet need. We're looking for the unmet needs because our role is that you may be waiting to make products unless there's something that's ready to go, and you can buy it, which even takes nine to 12 months. And, you know, you're going to be in a development process for anywhere between two years and five years. So, our job in global strategic marketing generally is about uncovering the unmet needs, trying to find them as early as you can, and then trying to find ways and solutions to meet those unmet needs".*

In discussing the insight definition, three interviewees recognised that the terms 'actionable and non-obvious' resonated with them - *"I like actionable, you know, having an insight which you can't do anything about is not particularly useful"* (TH1-I2). As a Principal Engineer put it, *"Whilst a great idea might not be achievable because of the constraints of the environment, manufacturing technology, material availability, you know, there are many constraints that mean an idea, whilst a great solution is not achievable, and thus, in terms of the customer is meaningless*". (TH1-I4). Consequently,

if there is no understanding of a pathway to solve a problem, then the actionable side of the insight is lacking. A Principal Engineer (TH1-I2) suggested that actionable and non-obvious aspects represent a test of customer insight; if the insight does meet these two criteria, then it is just a statement of fact.

Another consideration mentioned is the trade-off between the actionable insight and the resources available to execute the insight. For example, an insight may have been discovered. Still, if the resources prohibit that innovation from becoming a reality, then it cannot be actioned, *"Quite often, you can know there's an unmet need and know there is no way of answering it yet"* (TH1-I6).

The Marketing Director (TH1-I3) highlighted insights in two ways; an insight can be about the customer or what the customer is trying to do. That insights can be both a broad understanding and a deep specific knowledge, *"You understand a little more about the customer, but it doesn't mean there is any actionable creative solution to be addressed, it's just good information to have"* (TH1-I3).

The term 'solution' in the customer insight definition was discussed. The respondents agreed that an insight should contain an element of the solution to meet the actionable part. Still, they struggled with the term 'solution' itself, suggesting it went too far to a stage later in the NPD process. A Principal Engineer agreed that an insight contains a *"level of confidence that it will work"* (TH1-I6) but saw the word solution as too strong. This may be because the term solution is ambiguous, as it can suggest either an idea for a problem or a finished product. They also challenged the word 'product' in the definition. It was mentioned that an insight into product innovation might not necessarily be product-related. For example, it could be a new market positioning of an existing product. A customer insight may be more than the product. It may be a behavioural change from the customer. Consequently, the participants did not agree with either 'solution' or 'product' in the definition.

In summary, the participants supported that an insight is an expression of deep knowledge. They only partially supported that it was non-obvious, creative, and actionable. They did not support the idea that an insight is either a solution or product-related; the definition went too far down the development pathway.

Table 5-5: Evidence of Understanding Customer Insights

Theme	Representative Quotations
Understanding Customer Insights	*Insights would be so unlike a qualitative need, insight might be something that doesn't translate into specification; experience has taught me those other things, the user struggles to articulate, and these are what I would consider an insight.* (TH1-I1)
	Insights, in a sense, I think are easier because they are that kind of eureka moment. They come from, you know, a single event or something. (TH1-I2)
	Surgeons didn't actually believe that they needed that. So, they would not have had a value in that. We recognise that. We believed that there would be a value so that we went ahead and created it… So sometimes they don't necessarily know that there's a value, the team would not necessarily know that there's a value. (TH1-I3)
	It's much less well defined. I think an insight can perhaps be two things. And it can either be a piece of information, a statement, or of a problem that we as a company we're not aware of. (TH1-I4)
	It really was more work to get a creative insight, but they can be very, very useful and very desirable when you solve a problem. (TH1-I5)

Source: Author

5.5.3 Relationship of Customer Needs to Customer Insights

Once the definitions of customer need and insight were established, the interview turned to a discussion of the relationship between these two concepts. Establishing the definitions of each concept and then building the relationship assisted in answering RQ 1. Firstly, the participants explained how they saw the relationship in their own words; representative quotes are shown in Table 5-6.

In discussing the relationship between needs and insights, the interviewees confirmed that they do consider there is a relationship. But in their understanding, the concepts did overlap. The Principal Engineer (TH1-I4) stated:

> *"I think they complement each other. I would view needs as things that are explicitly stated. Insights are things you can infer or opportunities you can uncover from more detailed research or indirect feedback. So, there's a relationship as well. And between what are must-haves versus nice to have, so what are things that you need, table stakes for the product? If you don't have these, the product use won't be the product you want. And then what are customer delighters? I think some of those delighters may still come directly from the customer, and some of those delighters may be things that you uncover and*

from more detailed research like ethnography, like benchmarking, like identifying opportunities and other products" (TH1-I4)

Following on from this, it was suggested that needs are explicitly stated by the customer and insights are inferred opportunities (TH1-I2). To explain the relationship, a Principal Engineer (TH1-I1) referred to the Kano model. He suggested that the difference is that customer needs are seen as the must-haves and the performance needs, whereas customer insights are the delighters. He also confirmed that delighters are the unarticulated needs uncovered from observations of the customer doing the job. Another Principal Engineer (TH1-I4) mentioned that the team start by generating the articulated needs (must-haves and performance) and then begins to "*flesh out*" the insights around these needs.

The Marketing Director (TH1-I3) also stated they had experience starting with developing a list of top-level needs and then exploring those needs to find customer insights. He also stated it was an iterative process of refining the needs and insights. The "loop of refinement" (TH1-I3) starts with a broad insight into the product area, then a series of needs are developed based on the board insight, and he then refines the initial insight based on the development of the needs. The iterations continue until a satisfactory point is reached or the pressures of the business are to move on to the subsequent development stage. Another Marketing Director (TH1-I6) confirmed there was a time frame; the management team gave them three months to understand the problem and report back. However, a Principal Engineer said in their approach, "N*eeds are probably the starting point*" (TH1-I1). He stated that he first tries to understand all the customer needs (articulated and unarticulated) and uses this framework to craft a research plan to discover the insights.

In summary, it can be suggested that the following three attributes can define the relationship between needs and insights: 1) they complement each other and do overlap; 2) customers articulate their needs, but insights are unarticulated; and 3) insights follow the uncovering of needs. In addition, an iterative process evolves that drives a more profound understanding of the needs so that, in turn, deeper insights are discovered.

Table 5-6: RQ 1 Evidence of Understanding the Relationship between Needs and Insights

Theme	Representative Quotations
Relationship of Customer Needs to Customer Insights	*Don't think they are synonymous. I think they probably overlap.* (TH1-I1)
	They complement each other think, I would view needs as things that are explicitly stated. And insights are things that you can infer, or opportunities you can uncover from maybe a more detailed research or indirect feedback. (TH1-I1)
	Kano terminology, I would see a customer need is a 'I must have', an insight as 'a delighter'. (TH1-I2)
	You can generate needs, which then as you begin to flesh out, you can start to look for insights around those needs. (TH1-I4)
	If you had to lay out I would say that you start with insight, and that allows you to develop a series of needs. But I think you can do it the other way around; I think you can say work you can develop a series of needs. And then as part of that, the output of that process you can look for further insight that is specific to the needs and the in a product. (TH1-I4)
	First understand the needs. And then that gives you a framework for that deeper research to uncover insights. Your needs are probably the starting point. (TH1-I5)
	Benefits are largely customer insights. And quite often the customer needs are close to table stakes for a product. (TH1-I6)

Source: Author

5.6 RQ 2: THE INSIGHT DISCOVERY PROCESS

This section relates to RQ 2: How does the process of discovering customer insights unfold within innovation teams? The following sub-sections are organised and reflect the second-order coding; refer to Table 5-2 for the breakdown of the coding for RQ 2:

- Uncovering customer needs.
- Techniques used to discover customer insights.
- Customer needs and insight process.
- Emotional response to discovering customer insights.

5.6.1 Uncovering Customer Needs

The theme that emerged from the first-order coding was the activities undertaken to uncover customer needs.

It was reported that the innovation team take a structured approach to uncovering needs. The team do not start with engaging customers in market research; instead, the

team begin by asking internal staff for their thoughts on a high-level customer needs to build an initial understanding of the problem. At this point, the team have informal discussions with surgeons to define the problem further and obtain the surgeons' initial thoughts, building a deeper understanding. During these informal meetings, the questions are wide and varied and aim to understand the needs holistically. After this, the team begins constructing a market research plan to focus on a greater understanding.

The source of needs was discussed; this was predominantly surgeons, but it was also nursing staff and the people who work with the users, such as sales and marketing groups. However, it was stated that surgeons can be a little short-sighted and produce predictable needs that are only sometimes creative or forward-looking. *"It's not possible to simply ask a customer to please tell me your needs". I*t is a *"conversation, a piece of research to determine them"* (TH1-I4). For example, a participant stated the surgeon was aware he had an issue but did not make a connection between their problem and how the innovation project could address his need. Customers often have a problem in their world but do not know what to do about it, and it is the team's role to uncover these problems and connect them to solutions.

Furthermore, customers often need clarification on the value a need can offer. This can stifle the innovation team's progress by putting doubt on the project's goals, especially in a large corporation where innovation projects compete for limited resources. Other reported data sources were literature on the medical condition, competitor products and patent databases.

The term '*analogous products'* was used as a way of uncovering needs. The conversation with users would centre around these existing products to draw out their needs. An analogous product provides a baseline for benchmarking, looking for desirable features and functions from competitors. It can also provide negative controls, undesirable features and tasks that need to be improved upon or eliminated (TH1-I1). However, if a product is unique to the market, analogous products are not available to baseline. Consequently, it is more challenging to draw out customer needs because *"customers don't know what they don't know"* (TH1-I1).

Two types of face-to-face meetings that discussed customer needs were reported. Firstly, the innovation team had an internal meeting consisting of marketing, sales,

product development, design engineering, and industrial design. Marketing would represent the commercial considerations, Sales would represent the customer, and Product Development would take overall accountability and facilitate the discussion; both Design Engineering and Industrial Design supported the discussion. The second type of meeting was external, involving the innovation team plus the customers. The customers were surgeons, and fewer than five surgeons were usually present at each meeting. The reasons for holding meetings differed. One Principal Engineer (TH1-I2) stated that he had set up an internal meeting to discuss the technical challenge and try to solve the issue. On the other hand, during an external meeting discussion, a problem arose (about an hour into the whole day's meeting). At this point, the debate turned to investigating the situation.

5.6.2 Techniques Used to Discover Customer Insights

In discussing techniques to discover customer insights, ethnography was mentioned as a crucial technique. It should be noted that ethnography in the industry setting is not the same as ethnographic methods used in social science research, e.g., embedded in culture for long periods. Zaltman and Coulter (1995) referred to this type of industry research as consumer-ethnography. The innovation team spent time in the operating room observing live surgeries to understand the flow of the operation, from the setting up of the room to the surgical process and then the teardown and cleaning-up. The team filmed surgeons operating and the general operating room area to see how the staff circulated. The team would later watch these videos back in the office to *"notice patterns of behaviours"* (TH1-I2) with the intention of discovering insights.

When watching the video, the team were also looking for *"coping mechanisms"* (TH1-I1), actions the customer did not realise they were doing. As such, they did not know they had a requirement to reduce or eliminate the coping mechanism. The coping mechanism is a similar concept to task workarounds (Norman, 2013); these are actions a user takes because the product does not work the way the customer requires it to work. Additionally, the team looked for what was termed '*cognitive load'* (TH1-I5), i.e., the mental effort and stress required to perform tasks. Data was collected by filling out questionnaires on what was perceived as the most challenging tasks in the surgical process. The intention here was that innovation with these tasks could bring higher value

to the product. Other areas that the team paid attention to when observing surgeries are described as looking for the *"third hand"* (TH1-I2). The third hand is when a task requires two people to perform or one person and another body part (other than the hand), for instance, supporting an instrument on the stomach. Likewise, the team looked for areas where the user is distracted by operating the tool rather than attending to the surgery, as these were also opportunities for improvement. A Principal Engineer (TH1-I5) also reported that they had the customer watch the videos with the team. The customer saw how they moved in the operating room, realised they were inefficient, and suggested ways to improve their tasks.

Two interviewees touched upon the term VOC; it appeared to be a catch-all term for the process of finding needs. There was an example of a team performing *"pseudo stats on VOC"* (TH1-I2), where the team had analysed data from a large population. However, this missed the point by eliminating the outliers that could be the source of new needs. When analysing the market research data, a principal engineer stated that he finds time at the end of the process to sit down with an open mind to read the notes and opinions collected to formulate a conclusion and rationale. He no longer tries to analyse the data quantitatively as he has found this gives a false conclusion. He found that the quantitative analyses removed the outliers, the customer telling the important "*nugget of truth*". However, he acknowledged that *"it's subjective, and I just do my best to lay out all of the opinions and then draw a conclusion from those opinions"* (TH1-I2).

It was also recognised that along with a structured approach, needs can be uncovered by accident, serendipitously, where the team were not particularly looking to understand an initial need, but one appears, *"you're having a conversation, and there is an insight that the surgeon gives you that they don't realise and that just pings something in your mind. Actually, I could get around it with that technology"* (TH1-I6). The Marketing Director stated that it is their job to maintain conversations, keeping your ear to the ground to uncover needs continuously, *"sometimes it can be a single conversation, is an aha moment. But other times, it can be a building up of several conversations"* (TH1-I6).

Principal Engineer (TH1-I2) stated that there *"were design challenges to overcome but to create a product as such, but there was a level of confidence that the solution would*

overcome this particular problem". One example was that a new software technology became available, enabling a more refined analysis of the functional structures of the knee joint and the ability to translate this into engineering specifications. This facilitated the product design and solved a functional issue.

Table 5-7: Data Supporting the Discovery of Customer Insights

Theme	Representative Quotes
Uncovering Customer Needs	*The advantage of being in the room was that we were standing around a pile of instruments and able to argue over each other.* (TH1-I1)
	Marketing, engineering director, design engineer, myself and the engineering manager who is accountable for that or responsible for that part of the project. (TH1-I1)
	I find it amusing the amount of pseudoscience that gets applied, you know, a Likert scale. And then spend months doing complex statistics on something that basically was just someone picking a number on a line. (TH1-I2)
	Surgeons or the customer I think can give you a series of needs, but sometimes they can be a little short-sighted and a little predictable. (TH1-I2)
	The ecosystem is changing. But I think we do it within projects as well, I think, you know, certainly experience of it, you know, over the course of a development, the something will change, the scope of the disease will change, or a new product will become available, and we revisit user needs. (TH1-I4)
	Developing a new technology or a new product, and there's not an analogue for it that the customer is already familiar with, sometimes it's more difficult to draw out those needs because you don't know what you don't know. (TH1-I5)
	We regularly find and uncover need, and then build projects around that. And then are often told, well, you know, I'm not so sure about the value of that just yet. (TH1-I6)
	Our biggest problem in the company is we take too long to respond. (TH1-I6)
Techniques to Discover Customer Insights	W*e videoed a bunch of surgeons operating and, in that process, through observation, we noticed a pattern of behaviours that suggested surgeons being injured when we spotted it through the video.* (TH1-I2)
	Having the opportunity to actually spend time in an operating room and watch what customers do so whether it is the surgeon themselves, the scrub techs, the even the preoperative setting up of instrument rooms, the post operative tear down what central sterilisation does, just looking at it as it went through the process. (TH1-I3)
	Kind of interesting because having them watch, they're like, we don't realise what we're doing or how we're doing it or how often we are moving around the operating room. (TH1-I3)
	Two or three hands to do an operation, that was an opportunity for improvement. (TH1-I5)
	Where you were distracted from your job by having to manage the instrument rather than the surgical procedure, then that was an opportunity for improvement. (TH1-I5)

Theme	Representative Quotes
Emotional Response to Discovering a Customer Insight	*It's also incredibly stimulating to be in a problem-solving environment; waves of emotion were probably positive, negative, positive, negative, positive, negative.* (TH1-I1) *So, for me, that's the most powerful kind of insight I've ever actually been aware of in kind of 15 years, to be honest. I love collecting user needs and insights.* (TH1-I2)
Customer Needs and Insight Process	*And it was a moment of understanding when we started to lay out and actually put yourselves into the position of the user. And we have representatives from product development, and our very experienced sales marketing team as well. So, they were able to introduce, able to lay out the theoretical workflow, and we hit this roadblock where we realised that we were all doing what engineers do, which is provide a piece of paper and a pen and start to do the maths. And you said, Oh, yeah, that's fine. We can do the maths, but then putting ourselves into the shoes of the user and thinking what I actually want to sit and do the maths if I'm in the middle of a complex revision operation.* (TH1-I1) *We followed up with the surgeons and kind of said, what's going on here? Why, why is Why are you behaving in a certain way. And that, that was the first time that we first time that I'm aware of that anyone had really thought about sort of workplace injury for the surgeon.* (TH1-I2) *What that insight allowed us to do is we then went back through other videos, and all of a sudden, we were aware of the different behaviours that surgeons were doing that kind of corroborated that this was not just a, you know, a single incident that this was a recurring kind of problem.* (TH1-I2) *The technology has allowed us a greater insight into the anatomy and we're able to pull out a curve that is much more representative of the anatomy then we've been able to do previous. Our belief is our insight is that by adapting the geometry of the implant in the region of concern.* (TH1-I4) *I think it's because it's such a simple improvement. It really resonates with some of the whole implant systems innovative, but this is something that they didn't realise was a problem. And as soon as you see the solution to, they are drawn to it* (TH1-I5) *The aha moment was actually you can you've got something that you can give them much quicker, that the market would actually accept really well.* (TH1-I6)

Source: Author

5.6.3 Customer Needs and Insights Process

In considering the needs and insights process, the interviewees were able to describe their experience when the insights were discovered. For example, a Principal Engineer described the moment as a single event, *"you think, my goodness, I didn't know that before"* (TH1-I2). He said that he then started to ask other people, "*Did you know this?"* He often hears replies like, *"I didn't either"* he then feels he has discovered a new insight. Similarly, the Marketing Director stated, "*The nice aha moments are ones that when you see them, it's so simple, you wonder why it wasn't always there"* (TH1-I6). In referring to the process of problem understanding, a Principal Engineer stated, "*I firmly believe to solve a problem, you need to understand the problem. I find understanding the problem more interesting than coming up with solutions"* (TH1-I2).

In one example, a Principal Engineer (TH1-I2) discussed an insight moment when they discovered that the surgeon was holding the power drill oddly and had an assistant supporting the tool. The team found that the surgeon was permanently injured from doing surgeries over many years. After informally polling other surgeons, the team found this was a common complaint, discovering that if they modified the product design and surgical flow, they could minimise the occurrence of the injury.

> *"We followed up with the surgeons and kind of said, what's going on here? Why are you behaving in a certain way? And they explained because they had a wrist injury and had hearing loss and things. And that was the first time I was aware that anyone had really thought about some workplace injury for the surgeon. We were doing a debrief, we pulled up the video, we pulled up other videos, and all of a sudden, we realised that this wasn't kind of, you know, an N of one, this was potentially much bigger" (TH1-I2).*

Once the team knew what to look for, they reviewed the literature and found this was a published issue.

In another example of insight discovery, the innovation team thought advanced technology was required to meet the customers' needs. However, after in-depth research, the team found that the surgeons wanted something other than the proposed solution, a more straightforward design with much less functionality. So, the initial unmet need

required modification. The Marketing Director (TH1-I3) stated that the insight process took longer, and it was more work to understand the insight than expected. However, once the problem was discovered, it was more valuable and desirable. Instead of having a long development horizon, the team could develop a product in less time around this newly discovered insight.

> *"It's not robotics, and I don't know if anybody would say it's robotics. But the surgeons we interviewed, we did one-on-one interviews for like two and a half, three hours at a time with each surgeon. And all of them came back with the same thing. And they all said, 'why aren't you just giving me a Kincise, that can be seen by a camera or by AR goggles', which effectively is navigation. 'Give me something to hit that target. That's exactly what we want'. And I said, okay, well, what about the robotics piece? They said, 'well, you know, it's an automated handle'. And the fact is, it's not that you're trying to chase people who are doing robotics. It's just the other people who say they're doing robotics are doing something called active navigation"* (TH1-I3).

In another innovation project, the team was deeply involved: "W*e're talking about this thing every single moment of our waking lives"* (TH1-I1). Consequently, the team did not consider that the product had a fundamental issue. As a result, when a critical problem with the design occurred, the team had to take a step back and were able to discover a more considerable insight that solved many minor issues. A Principal Engineer explained that *"it was a moment of understanding when we actually put ourselves into the position of the user"* (TH1-I1). The users faced this problem with product sizing and size conversion, but they had not been able to articulate it. So, the engineering team worked through the problem and realised the surgeons did not have the time to do the size conversion during complex revision hip surgery. After a short investigation, the insight was a simple modification to the sizing nomenclature to make the product size range equivalent across the system. The principal engineer stated, "*we were solving one problem and discovered a non-mechanical solution that fundamentally enhances the system"* (TH1-I1). The moment of knowing was when the team discovered they were trying to solve the wrong problem. Once the real problem was found, then the insight and

solution were obvious. Describing the meeting in detail, the Principal Engineer (TH1-I1) stated:

> *"It was one of the rare face-to-face meetings that we held. The meeting was set up specifically to discuss this. The way in which our different sub-families would work together. And to that, up to that point, we haven't discussed nomenclature. And it was a moment of understanding when we started to lay out and actually put ourselves into the position of the user. And we have representatives from product development and our very experienced sales marketing team as well. So, they were able to lay out the theoretical workflow, and we hit this roadblock where we realised that we were all doing what engineers do: providing a piece of paper and a pen and starting to do the maths. And you said, 'Oh, yeah, that's fine'. We can do the maths but then putting ourselves into the shoes of the user and think, what do I actually want to sit and do the maths if I'm in the middle of a complex revision operation? Probably not so. The advantage of being in the room was that we were standing around a pile of instruments and able to argue with each other. I don't think we walked into the meeting knowing that we had a problem with nomenclature. But we knew that we had a technical challenge. A specific problem happened about maybe an hour into the it was a three, three plus hour session. By roughly the third hour, would have been pressure testing the proposed solution".*

In a final example, a Principal Engineer (TH1-I1) explained an insight that led to a product modification but had a disproportionate benefit to the customer. During the ethnographic stage, the team saw that users had difficulty placing the medical device in the knee joint. One of the industrial designers created a simple design feature to address the problem. When it was presented, the surgeon group responded, '*Why wasn't this done before?*':

> *"In orthopaedic procedures, you position jigs and fixtures on the bone and then cut through them using an oscillating saw; those fixtures are either positioned on the bone, or you have another instrument if it's pinned in the right place, and you mount the cutting block on them. In part of the ethnographic work, it was identified that there's a huge number of times surgeons are putting blocks on and*

off pins on the bone. And you are trying to line two pins up with two holes that are on the back of the block. One of the industrial designers put two slots, so there was a lead in the hole. So, you could drop the two slots onto the pins and then flip it around, and it is located in the holes. That was something nobody had articulated that they wanted. But it was an observation from ethnographic work. And it's probably one of the simplest but most well-received features on a kit" (TH1-I2).

From the perspective of where the customer insight came from, it was reported that both the customer and the innovation team discovered them. However, after further discussion, the customer was typically the source of the product issue, and the innovation team (engineering, design engineering and industrial design) understood the problem and generated the insight after the meeting - back at the office.

Two interviewees touched upon the time for the insight discovery. One interviewee described two scenarios that he had experienced; first, the insight could take a considerable time to be discovered, and second, he said that there have also been instances when, *"Insights can be uncovered over a considerable time, or they can be a wham bam moment"* (TH1-I6). Another participant (TH1-I4) explained that it took a couple of weeks, then corrected themself and said a couple of months.

Two interviewees talked about the amount of development time to address the insights. Firstly, the Marketing Director (TH1-I6) stated that the response time could be shorter due to the company's size and that the window to address the insight sometimes passes. Building on this, a Principal Engineer (TH1-I2) mentioned that the ecosystem (competition, new products, medical knowledge, and the scope of the disease, etc.) in which the product is situated changes during development; thus, the insights may require reviewing. Furthermore, the innovation team's understanding of the ecosystem and user issues also evolved during the product development process, which also impacted the established customer needs and insights.

5.6.4 Emotional Response to Discovering Customer Insights

The emotional response when an insight had been discovered was discussed. Firstly, one Principal Engineer reported how he felt during the process, "I*t was great, great fun… it's*

also incredibly stimulating to be in a problem-solving environment" (TH1-I1). During this creative period, the participants experienced waves of emotion each time they worked through a problem. They found a new or better solution when they hit another issue that needed to be solved. In the end, the level of satisfaction throughout the innovation team was visible. Another Principal Engineer (TH1-I3) described that he loves collecting insights, and even though there may not be an innovation project to apply them to, the process of knowing was satisfying. He described an insight process example:

> *"So, for me, that's the most powerful kind of insight I've ever actually been aware of in 15 years. To be honest, having had such a strong example, everything else kind of, you know, pales in comparison. Maybe there's an oddity of insights that you, you know, the next one needs to be more dramatic"* (TH1-I3).

The Principal Engineer (TH1-I3) concluded that he, *"Loves collecting user needs and insights… I really enjoy it. I firmly believe that to solve a problem, you need to understand the problem. And I actually find understanding the problem more interesting than coming up with solutions".* The two participants were not prompted to discuss the emotional aspect but felt it was an important point to bring up. Though this research does not look at the emotional aspects of insight discovery, it is an opportunity for future research.

5.7 REFLECTIONS ON FEASIBILITY STUDY

The experience gained from the feasibility study was reflected upon before proceeding to the main study so that changes to the research design, data collection plan and interview guide could be incorporated. The research method with the semi-structured interviews proved to be suitable for answering the RQs. Detailed feedback from the interviewees is captured below:

- The participants agreed the interview aim was clear with what they were being asked to think about and discuss.
- In the first interview, the researcher needed to clearly explain that the origins of the definitions were from the literature, which confused the interviewee about what they were being shown. Instead, the researcher went straight into

the interview without sufficient preamble and scene-setting. For the remaining five interviewees, the origins of the definitions were clearly explained.

- In the first interview, the researcher needed to explain clearly the confidentiality of the information at the start. Consequently, the interviewee was not open to sharing the project details. This was modified for future interviews; confidentiality and anonymity were explained at the beginning.
- The interviewees preferred the conversation approach of the semi-structured interview.
- All interviewees agreed that the question order made sense – definitions first, relationships, and then their insight discovery experience.
- When the researcher listened to the recordings, the responses after the interviewee talked felt slightly abrupt and not engaged with the answer, for instance, "Yes, ok, great, thank you". Learning was listening to what the interviewees said and not rushing to the next question.
- When asked if the interviewees would have liked a primer email a week before the interview, the following responses were given:
    - One interviewee liked the *"stream of consciousness"*. An email explaining would not have been helpful, *"If you allow someone to think about the answer, they may give you a different answer than going off the top of your head"* (TH1-I1).
    - Another interviewee suggested it would have been helpful to have a short primer email to allow him to think about the insight beforehand.
- In response to these comments, the researcher will:
    - Provide an introduction at the beginning of the interview, explaining the interview steps and sections and covering confidentiality, anonymity, the background to needs, and insights.
    - Prepare a brief email explaining the interview subject, confidentiality, and anonymity. But I will only expect some to read

it. Clearly state that no prework is required, as this may put off busy people from participating.

The feasibility study showed that the questionnaire provided the discussion direction. However, the order and style of the questions were modified as the researcher learned from the responses and the follow-up questions.

5.8 SUMMARY OF THE FEASIBILITY STUDY CHAPTER

Chapter 5 presented the findings of the feasibility study, known as Thackeray. The following three conclusions can be made.

First, it appears from the six interviews that there is a relationship between customer needs and customer insights. There is an iterative loop; when further market research is conducted, the initial understanding modifies both the needs and insights. Furthermore, the Kano model (must-have, performance, delighters) may help to explain how these concepts relate – the must-have and performance equal customer needs and that the delighters (or unmet and unarticulated needs) equal customer insights. However, even between the six interviewees, there was no clear agreement.

Second, the interviewees were able to report that they did use a process for the discovery of customer insights. This process involves iterating and refining both the customer needs and insights by engaging customers using techniques such as observation and interviews. It was also reported that customer insights can be discovered serendipitously. Though chance discoveries can occur, the insights are still verified and built upon by the team. The teams use analogous products to assist the customers in verbalising their needs. Coping mechanisms, cognitive load and the ‘third hand’ were also used to uncover the problems customers encounter.

Finally, examples of insight discovery were described by the interviewees. They showed that customer insights are discovered from various types of interactions with customers and that the discovery can either occur quickly or take time to build. But once discovered, there appears to be this moment of understanding - the aha moment.

CHAPTER 6 PILOT CASE STUDY

6.1 INTRODUCTION

Chapter 6 presents an example of a retrospective pilot case study, which is referred to as Spark (Case Study 1). The study will utilise the research method proposed in Chapter 4. The product innovation studied for this case is a hip reconstruction (total hip arthroplasty) software planning system for the orientation of the acetabular cup position in the acetabulum (hip socket). Acetabular cup positioning is one of the most critical steps in total hip arthroplasty. A malpositioned component can result in dislocations, impingement, limited range of motion, and increased polyethylene wear. The new software technology solution represents a new product offering for the company, which has traditionally manufactured hip and knee reconstruction medical devices. The chapter will present a within-case analysis that is based on the pilot case study plan presented in Chapter 3, Section 3.7, and discusses the following:

- Background on the case
- Data collection methods
- Collected data
- Data analysis
- Preliminary conclusions
- Lessons learned from the pilot case study

6.2 DATA COLLECTION

The data sources consisted of interviews and company documents.

6.2.1 Interviews

Data collection took place over three weeks. The four semi-structured interviews were scheduled in the interviewee's Outlook calendar. The researcher used his company email account for all communications to facilitate access and response. The interviewees covered both marketing and R&D functions. Additionally, email communication was

used after the interviews to clarify any points raised. A summary (Table 6-1) of each interview shows the details of the participant's role and responsibility, interview duration, and date. The total duration of the four interviews was 3 hours 31 minutes.

Microsoft Teams was used for each interview, which lasted an average of 53 minutes. The interview was recorded with a camera using the Microsoft Teams recording function. The first two minutes were spent explaining the research and the interview process. After this, the interviewee described their role and experience. The remaining time was used for the semi-structured interview using the interview guide shown in Appendix B.3. The interview recordings were transcribed using the auto-transcription service in the NVivo software; after the auto-transcribe, the researcher proofed the transcript by listening to the recording and modifying any transcription errors.

Table 6-1: Interview Details for Spark

Case Interview Number	Role, Job Title	Case Participant	Experience	Date	Interview Duration (min.sec)
1	Industrial Designer	C1-I1	10 years in current company, total 20 years' work experience	January 2022	61.09
2	Marketing Director	C1-I2	10 years in current company, total 20 years' work experience	January 2022	56.32
3	R&D Lead Engineer	C1-I3	15 years in current company, total 15 years' work experience	January 2022	48.59
4	Enginee r	C1-I4	Two years in current company, total two years' work experience	January 2022	44.44
				Total	210.44

Source: Author

6.2.2 Documents

Five relevant project documents were collected from the interviews. Table 6-2 lists them.

Table 6-2: Document Details for Spark

Document Number	Title	Document Content	Number of Pages	Date	Author
C1-D1	Target Product Profile (TPP)	Marketing strategy and Business case; Clinical benefits; value proposition	19	May 2021	Marketing Manager, Lead Engineer
C1-D2	Front end slide presentation	Strategy presentation to management on the project, status, and direction	20 slides plus ten back-ups	July 2021	Marketing Manager, R&D Lead Engineer
C1-D3	Requirement Traceability Matrix (RTM)	Flow-down of Customer and design requirements	Excel file Six printable pages	October 2021	R&D Lead Engineer, Engineer, Industrial Designer
C1-D4	UX workflow	Figma UX prototyping software (Figma, Inc). shows how the software flow works and UK environment	Single screen	November 2021	Industrial Designer
C1-D5	Cadence stage-gate guidance v11	Instruction on the Cadence stage-gate process & overview slide	25	October 2021	Business Unit

Source: Author

6.3 RQ 1: RELATIONSHIP OF CUSTOMER NEEDS TO CUSTOMER INSIGHTS

This section addresses RQ 1: How are customer needs related to customer insights in practice in the work of innovation teams at the front end of innovation? RQ 1 is not based on the case study directly. The results from the interviews have been broken down into three sections: 1) understanding customer needs, 2) understanding customer insights, and 3) the relationship of customer needs to customer insights. This structure was chosen as it is the same as the interview structure. Firstly, the participant was asked to define in their own words a need, an insight, and their relationship. Secondly, the participant was shown PowerPoint slides (refer to Appendix B.6) that had the definitions for a need and insight that were created from the SLR and asked to comment on them. The SLR definition for a customer need is "A statement crafted by the innovation. team that interprets the market research data and defines the customer's future benefit from and value of a product's use" (refer to Section 2.5.2). The SLR definition for a customer

insight is “A customer insight is an expression of deep knowledge about customers that leads to an actionable non-obvious, creative solution” (refer to Section 2.6.1).

6.3.1 Understanding Customer Needs

The interviews began by exploring the participant's understanding of customer needs. Initially, it was stated that they typically use the terms ‘*user needs'* and '*customer requirements'* interchangeably with customer needs. The four participants responded to their own words that generally agreed with the SLR definition (refer to Table 6-3), *"it resonated…it makes perfect sense"* (C1-I1). The Marketing Director stated he also uses '*unmet need'*, the unmet need is defined as *"something that is going on in the market that we know is an issue*" (C1-I2). Additionally, needs must be seen as beneficial for the customer and once found, could have a *"big impact on their lives in the right way and do the job it's meant to do"* (C1-I2). As shown in Table 6.3, the summary responses from the participants demonstrate that they understand customer needs; they use terms such as ‘customers have a problem’, ‘outcomes people want to achieve’, and ‘beneficial and useful to them’.

When gathering the customer needs, the Engineer (C1-I4) confirmed that he does not simply take what the customer says they want and then implement a feature or function around the stated want. He considers what is plausible, realistic, and implementable, *"just because a customer wants it, this doesn't mean that it will be fully or partially provided"* (C1-I4).

Table 6-3: Participants’ Definition of Customer Needs

Theme	Representative Quotes
Understanding Customer Needs	*A user need would be anything that would drive a programme and influence your solution* (C1-I1)
	A particular thing that our customers have a problem with. An unmet need is something that is going on in the market, that we know is an issue, and that there isn't a true solution to that thing, because obviously, what we're trying to do is find a new area to sell (C1-I2)
	I like the idea of describing user needs as outcomes that people want to achieve. So, tasks that they need completed (C1-I3)
	How we can deliver something that is beneficial and useful for them (C1-I4)

Source: Author

The participants reviewed the customer need definition from the SLR in the PowerPoint presentation (Appendix B.5); their responses are captured in Table 6-4. The definition was shown in full and then broken down into three components. In reviewing the full definition, the Marketing Manager (C1-I2) suggested that the definition is closer to a value proposition. He stated that a *"value proposition is one step further. It's where you take the customer need and frame it with what you're going to do about it"*. Further, *"a customer need doesn't necessarily have future benefit in there. It's more about what it is that we know what the unmet need is. What is the problem? What is the problem we are trying to solve? When I think about a customer need and then the value proposition, it is something more like that, here's the problem and in solving that problem, here's what added value you can deliver*". The R&D Lead Engineer (C1-I3) also had an issue with the term's 'benefit' and 'value' in the definition, as he felt these were "*loaded terms*" and that a need does not clearly state a benefit. However, after further thought and rereading the definition he agreed that with benefit is a crucial consideration but clarified that the, *"Devil is in the detail"* with how benefit and value are defined. He also (C1-I3) stated, *"Value being the worth of something? How are they going to pay for it? A lot of needs are not things that someone would pay for. But actually, those are the ones that, if you fail to deliver them, will completely tank the project".* As such, the need definition should clearly state that value and benefit may not only be in monetary value but could be viewed holistically for all the needs. The Engineer (C1-I4) acknowledged that the term 'future' also plays an important role in value and benefit*:*

> *"I guess I never thought about it that you can't design something that the customer wants right now. It has to be for the future because this product is supposed to be leaping ahead of time versus delivering something now. So, you create something now, and two years down the line, when it was put in the market two years ago, is that something that they now want? And so, I think that's a good point. It's just the timeline of it. You have to be cognizant of where it falls in the customer's needs and where they'll where you see them being"* (C1-I4).

In assessing the first component of the definition, 'A statement crafted by the team', all four participants supported this was reflected in their practice. There were no

disconfirming quotes. Considering the ‘reflects the customers' future’ and ‘value and benefit of a product’s use’ components of the definition, the Industrial Design, Engineer, and Lead Engineer all supported this. However, the Marketing Director did not; he saw that the customer did not know what future benefit a new product could provide, and the value aspect was more associated with the value proposition.

In summary, the participants confirmed they supported the idea that customer needs are owned by the customer but are crafted by the team. However, the definition's future benefit, value, and solution portions were only partially supported. Table 6-4 shows the definition component and the explanation of the definition; it also provides an indicator for the participant’s response (+, - or not mentioned (NM)), with the associated supporting or disconfirming quote. For example, it can be seen from the table that the definition ‘reflects the customer’s future’ was supported by three participants (C1-I1, -I3, -I4) but not supported by the Marketing Director (C1-I2). The instrument in Table 6-4 assisted in building a picture from all the participant’s responses to the customer need definition.

Table 6-4: Participant's Response to the Customer Need Definition from the SLR

Component of Customer Need Definition	Explanation of the component of the definition from SLR	C1 -I1	C1 -I2	C1 -I3	C1 -I4	Supporting Quotes	Disconfirming Quotes
A statement crafted by the team	The innovation team analyse the market research data and interprets (crafted) this into a sentence/ commentary that captures what the customer wants.	+	+	+	+	*You can't necessarily take exactly what a surgeon says and implement that exact same thing, you have to be able to think about is plausibility, its realistic-ness, its implementation.* (C1-I4)	
Reflects the customer's future	Though the customer need is interpreted by the team (reflect), the customer still owns the customer need. As such, the need can change if the market or environment changes for/by the customer (future).	+	-	+	+	*You can't design something that the customer wants right now. It has to be for the future because this product is supposed to be leaping ahead of time. You create something now and two years down the line when it's put in the market, which is two years ago, is that something that they now want? And so, I think that that's a good point is just the timeline of it.* (C1-I4)	*A customer need doesn't necessarily have future benefit in there. It's more about what is that we know what the unmet need is. What is the problem? What is the problem we are trying to solve? (*C1-I2)
Benefit from and value of a product's use	What will the customer gain (value and benefit), and the job they can perform better (product's use)	+	-	+	+	*Value being the worth of something. How are they going to pay for it? A lot of needs are not things that someone would pay for. But those are the ones that if you fail to deliver them will completely tank the project.* (C1-I3)	*That statement is more something closer to a value proposition than a customer need. Value proposition is one step further, it's where you take the customer need, and you frame it with what you're going to do about it.* (C1-I2)

'+'. This is a positive response (agreement) from the participants to the definition component.

'-'. This is a negative response (disagreement) from the participants to the definition component.

'NM'. Not Mentioned; means that the participant did not specifically discuss this aspect during the interview.

Source: Author

Table 6-5: Participants' Response to the Customer Insight Definition from the SLR

Component of Customer Insight Definition	**Explanation of the component of the definition from SLR**	**C1-I1**	**C1-I2**	**C1-I3**	**C1-I4**	**Supporting Quotes**	**Disconfirming Quotes**
Expression of deep knowledge	The innovation team gain a unique interpretation and comprehension of the customer needs and market research data	+	+	+	+	*Those hard-fought nuggets of information that were perhaps difficult to obtain but have the opportunity to kind of be a delight to give you that disproportionate benefit.* (C1-I3)	
Actionable	Is practical and implementable	-	NM	-	NM		*I don't think they all have to be actionable.* (C1-I1)
Non-obvious, creative	Restructuring the problem and recombining data to create unexpected ideas	-	+	+	+	*They're the thing the information your customers are giving you. That is making you think there's an unmet need, there's a problem, there's an issue.* (C1-I2)	*Aren't necessarily, non-obvious creative solutions.* (C1-I1)
Solution		-	-	-	NM		*I think the creative solution comes further down the road.* (C1-I2)

'+'. This is a positive response (agreement) from the participants to the definition component.

'-'. This is a negative response (disagreement) from the participants to the definition component.

'NM'. Not Mentioned: This means that the participant did not specifically discuss this aspect during the interview.

Source: Author

6.3.2 Understanding Customer Insights

After discussing customer needs, the next component in understanding the relationship between needs and insight was assessing the definition of customer insights. Therefore, the following section considers the participant's understanding of customer insights. To begin, the four participants responded in their own words; examples are shown in Table 6-6. The R&D Lead Engineer explained that insights are, *"just that, those hard-fought nuggets of information that were perhaps difficult to obtain but have the opportunity to delight in giving that disproportionate benefit"* (C1-C3). The Industrial Designer (C1-I1) explained that, *"I think an insight is a direction, a good starting point, but it may not be your vanishing point that makes any sense*" and further stated that it is *"Insight into their world, into their reality and to their problems and their struggles and gives you an idea of their day-to-day"*. The Marketing Director stated that insights are a statement of a problem that the company is not yet aware of; they come from pieces of information that customers, *"Give you, willingly, or sometimes unknowingly"* and have, "*Lifted the lid a little bit, and I understand that a bit better now"*. This more profound knowledge can lead to a customer insight (C1-I2).

Table 6-6: Participants' Definition of Customer Insights

Theme	Representative Quotes
Understanding Customer Insights	*I think an insight is a direction, a good starting point, but it may not be your vanishing point that makes any sense.* (C1-I1)
	Is that piece of information, you don't always know, you don't always have a solution for it. But it's recognising that it's a problem. It's not one comment is not one bit, it's a whole set. (C1-I2)
	I also think experience has taught me those other things the user struggles to articulate, and these are what I would consider an insight. Those hard-fought nuggets of information that were perhaps difficult to obtain but has the opportunity to kind of be a delight to give you that disproportionate benefit. (C1-I3)
	It's definitely based on like perspective experience. What someone sees, someone else doesn't see two different lenses to the problem. (C1-I4)

Source: Author

The participants reviewed the customer insight definition from the SLR in the PowerPoint presentation (Appendix B.6); their responses are captured in Table 6-5. The definition was shown in full and then broken down into four components. In reviewing the full definition, the R&D Lead Engineer suggested that it is a test to verify an insight's

actionable part, *"I've observed something about our users, but I have no idea what to do with it—having an insight which you can't do anything about is not particularly useful. I like actionable because it helps make it clear that you need to be able to do something about this for it to have useful insight"* C1-I3. In contrast, the Industrial Designer (C1-I1) was concerned with the actionable solution aspect, *"Insights aren't necessarily non-obvious creative solutions. I don't think they all have to be actionable"*.

The R&D Lead Engineer (C1-I3) expressed concern regarding the word 'solution' in the definition, *"But it's also not easily solved. And so, I think there needs to be an element of solution in there. But this, kind of, jumped straight to the solution, and that feels that it kind of feels like a later stage in the process for me"*. Considering an innovation team's input, the Engineer (C1-I4) stated, *"they are in their role, and they have a certain perspective on what they do. And so, with their experience and perspective, they have some insight into what the product should look like based on their perspective and experience. What someone sees, someone else doesn't see - two different lenses to the problem"*.

In summary, the participants only supported the idea that insight is an expression of deep knowledge. They only partially supported that it was non-obvious and creative and did not support that an insight is neither actionable nor a solution. For them, the definition went too far down the development pathway. Table 6-4 shows the definition component and the explanation of the definition; the table also provides an indicator for the participant's response (+, - or NM), with the associated supporting or disconfirming quote. For example, it can be seen from the table that the definition 'non-obvious, creative' was supported by three participants (C1-I2, -I3, -I4) but not supported by the Industrial Designer (C1-I2). The instrument in Table 6-4 assisted in building a picture from all the participant's responses to the customer insight definition.

6.3.3 Relationship of Customer Needs to Customer Insights

Once the definitions of customer need and insight were established with each participant, the interview turned to a discussion of the relationship between these two concepts. The strategy of establishing the definitions of each concept and then building on these into the

relationship supported answering RQ 1. Firstly, the four participants explained how they saw the relationship in their own words; representative quotes are shown in Table 6-7.

Table 6-7: Participants' Understanding of the Relationship between Customer Need and Customer Insight

Theme	Representative Quotes
Relationship of Customer Needs to Customer Insights	*Insight could come from a customer and the need comes from both the customer and development team.* (C1-I1)
	Boxy clusters of insights will influence and evolve into user needs. Needs evolve out of insights. There were loads of needs that came out of that, that started with insights. (C1-I1)
	Empathy drives insights, which drives needs. (C1-I2)
	I think of it as I think the whole topic is user needs. Within user needs, I would consider insights to be a subset of difficult-to-find user needs that offer the potential for benefit. (C1-I3)

Source: Author

In discussing the relationship between a need and insight, the participants agreed they are two separate concepts. For instance, the Industrial designer (C1-I1) stated, *"It's very important and critical to differentiate the two because not all insights are needed"*. He also concluded that customer needs come from insights; *"once you collect all your data and analyse and scrutinise all of your market user research, boxy clusters of insights will influence and evolve into user needs - needs to evolve out of insights"* (C1-I1). Furthermore, the Lead R&D engineer (C1-I3) stated, "*And bingo, that insight became a user need"*. The Industrial Designer (C1-I1) also said that insights have the potential to generate lots of needs, *"there were loads of needs that came out of what started with insights"*. He (C1-I1) indicated that *"a single individual's insight or idea isn't enough to build a project off of or set a direction off".* However, the Lead R&D Engineer (C1-I3) also said, "*I think of it as the whole topic is user needs. Within user needs, I would consider insights to be a subset of difficult-to-find user needs that offer the potential for benefit. Insights, for me, are a subset of user needs. User needs are a blanket term";* though needs come from insights, they are still part of the needs process. Finally, they agreed that gathering customer needs and insights was their favourite part of the design process - hearing what the customer wants, making sense of this in the product innovation context, and then interpreting this into needs and insight, ultimately evolving into a tangible output.

Table 6-8: Participants' Description of the Relationship between Customer Needs and Customer Insights

Case Participant	Relationship	Sequence	Representative quotes by Participant
C1-I1	Connected	Insights to Needs	*It's very important and critical to differentiate the two because not all insights are needs.* *I think insights can become needs; needs evolve out of insights.* *Empathy drives insights, which drives needs.*
C1-I2	Connected	Fluid	*I still think they're just really fluid.* *I think they're quite heavily influenced by context.*
C1-I3	Subset	Not mentioned	*I would consider insights to be a subset of difficult to find user needs that offer the potential for benefit.*
C1-I4	Not mentioned	Not mentioned	

Source: Author

A summary of the participants' feedback on the relationship between needs and insights shows that they agree they are separate concepts, have interaction, and are connected. Table 6-8 summarises the relationship feedback from the participants, each with representative quotes. For example, it can be seen in Table 6-8 that the Lead Engineer (C1-I1) viewed the relationship between needs and insights as connected and that the sequence was an insight to need. Nevertheless, there was no agreement on the sequence between needs and insights in the team. From these findings, it can only be stated that needs and insights influence each other and drive a deeper understanding of the customer's problems.

6.4 RQ 2: THE INSIGHT DISCOVERY PROCESS

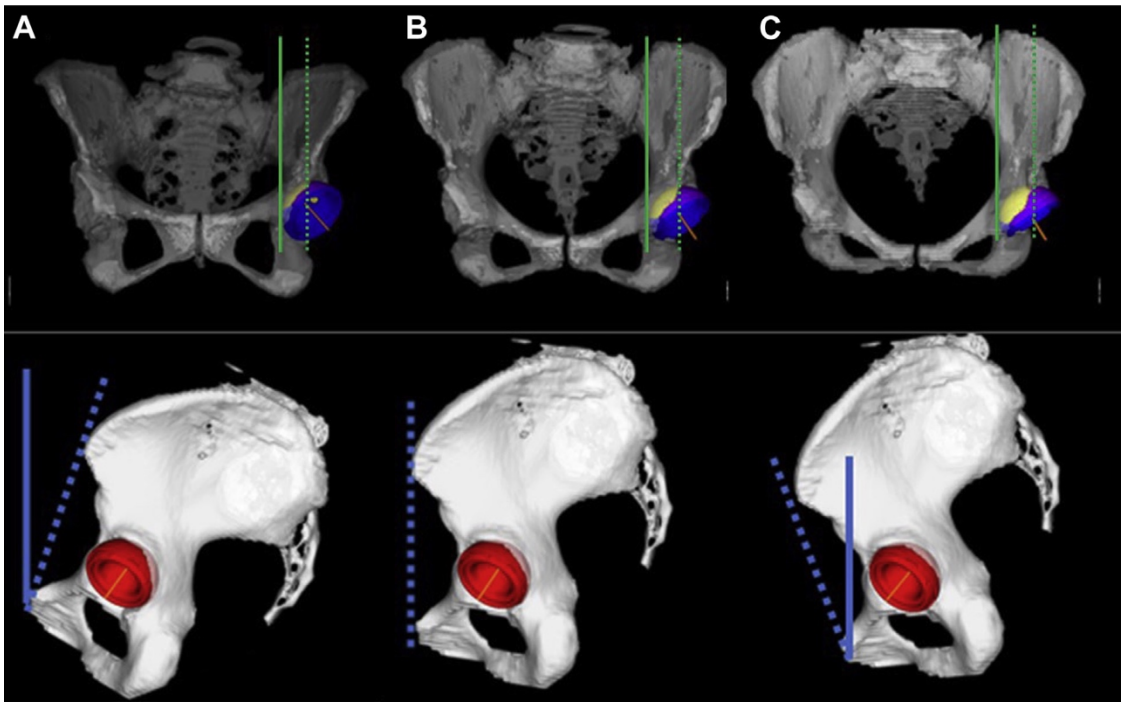
This section will now consider the findings for RQ 2: *How does the process of discovering customer insights unfold within innovation teams?* The analysis was based on interviews and documents and will show the insight discovery process that the team followed for the project. It was found that the team followed the formal Cadence Stage-gate process for the FEI. They also undertook other activities in the process.

6.4.1 BACKGROUND TO THE CASE STUDY

The Spark case study (CS1) was based on a division of a multinational healthcare company. The case study involves a subsidiary business unit that specialises in developing, marketing, and selling joint reconstruction (hip and knee) medical devices. The marketing and R&D functions are in both the UK and the USA. The business unit is one of the top three in their market. The business unit was selected as it is actively developing new products and working with customers, and the researcher has contacts in the business unit.

The specific project chosen for the case study is a hip planning software solution, which allows healthcare professionals to utilise hip and pelvic X-rays to position the acetabular cup prosthesis in an optimal orientation to maximise the range of motion and limit the potential for dislocation of the femoral head from the acetabular cup. In addition, cup positioning is required with reference to the spinal pelvic tilt. Figure 6-1 shows a software screenshot for anterior and lateral views of the pelvis 3D scans with the acetabular cup, colour-coded red and blue, respectively (Ueno *et al.*, 2019)

Figure 6-1: Computer Graphic showing Acetabular Cup Position



Source: Adapted from Ueno *et al.* 2019

The project was initiated to complement the existing computer-assisted surgery system product offering known as Velys. A competitor (Corin Ltd) was already on the market with a similar solution and was taking market share from the case study business unit. Therefore, senior management required an urgent solution to compete. The innovation team consisted of four people from Marketing, Engineering, Industrial Design, and Software Engineering. The FEI lasted 11 months; at the conclusion of the FEI, the project was chartered (Cadence stage Gate C). The team created the application prototyping using Figma (Figma, Inc.). This process allowed the innovation team to progress rapidly through multiple design iterations as Figma enables fast design conception with limited software engineering. The goal of each design iteration was to understand the planning workflows and what data to present to the users through the user interface.

Access to the interviewees within the business unit was achieved by contacting the team members through the company email system. Then, if the potential interviewee agreed that they had the time and confirmed they had the relevant experience with the project, a Microsoft Teams virtual one-to-one meeting for the interview was set up in their calendars. Consent to be interviewed was established via email. At the commencement of the interview, the researcher stated confidentially and anonymity, and verbal agreement was recorded. Following this, the interviews were transcribed and coded using the methodology described in Section 4.6.

6.4.2 Coding of the Interviews and Documents

6.4.2.1 First-Order Concept Coding

The following steps were undertaken for the first-order coding. In the first step, the four video interviews were uploaded into NVivo and translated with the NVivo translation module. In the second step, the interviewee's attributes were coded, as shown in Table 6-1. The next step involved reviewing the transcript's structure, which is a broad look at the data. This helped to highlight the areas in the transcript that related to specific interview questions. Next was descriptive coding, which summarised the sections (sentences or paragraphs) used by the participants. The descriptive coding step is where the SLR provision coding list was used (Appendix B.1). The SLR provisional coding list

was determined and generated from the literature review before the data collection stage, and this is helpful before starting the data analysis coding process. If an existing code did not best describe the phrase, then a new emergent code was created. The documents were also coded using the provision coding list and emergent codes. The in-vivo and process coding looked for specific words; these again were coded either by using the existing codes from the previous step or by creating new emergent codes. The coding analysis described above used the approach detailed in Section 4.6.

The first-order coding created 54 codes in total - 19 provisional and 35 emergent. The coding resulted in 182 references across the four transcripts. For example, Figure 6-2 shows a section (screenshot from NVivo) of an interview transcript from the Industrial Designer (C1-I1) with the highlighted first-order codes.

6.4.2.2 Second-Order Theme Coding

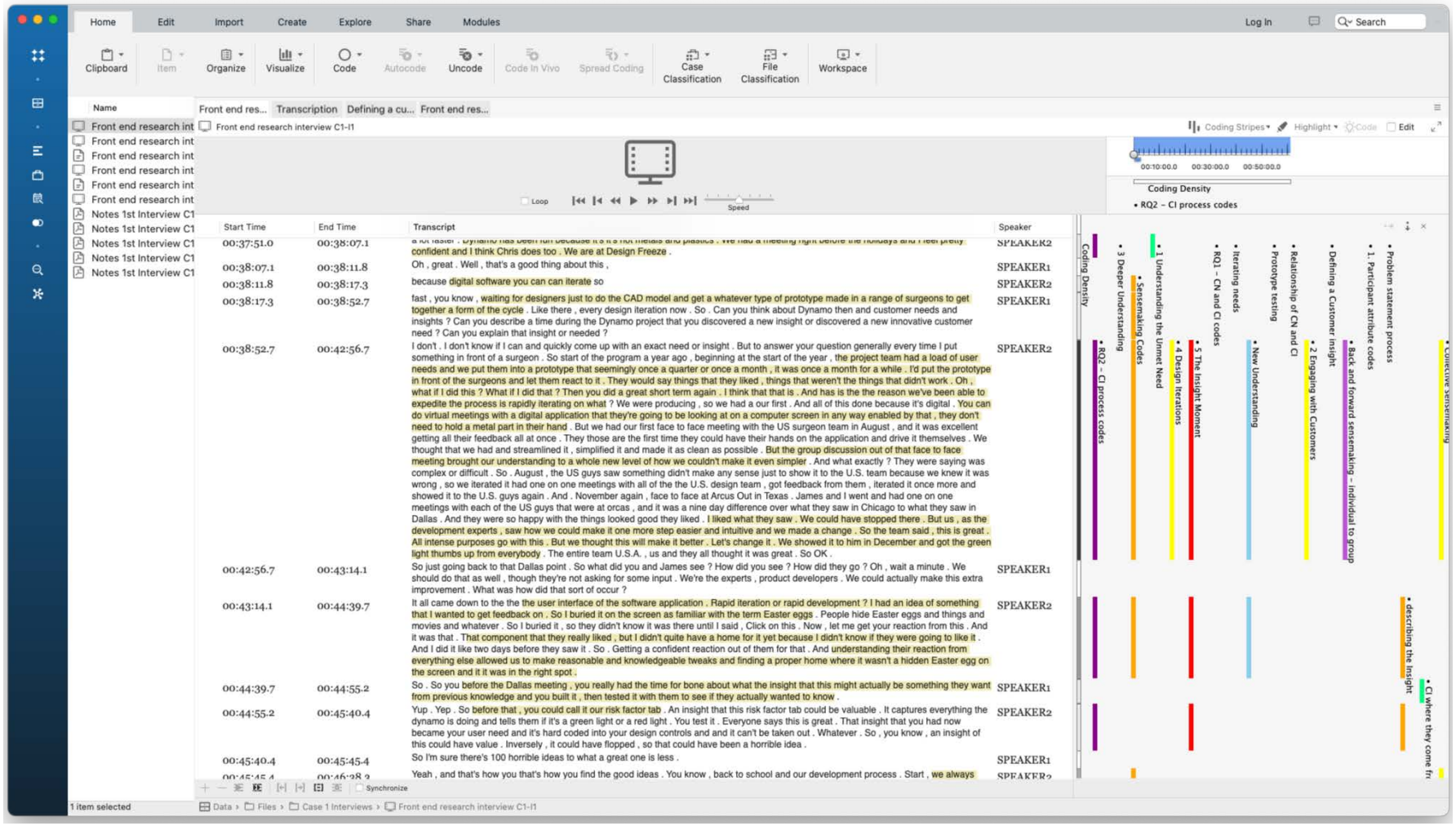
Second-order theme coding analysis involved combining two or more first-order codes to synthesise the codes into themes. These emerging themes suggested concepts that answered the RQ. Table 6-9 shows the second-order themes and, first-order codes, and representative quotes. Appendix C.1 contains a coding structure table with the second-order themes and first-order codes and their associated number of codes. This coding structure relates to this case study only; for subsequent case studies, a new coding structure was created, which will use the provisional codes and emergent codes specific to the case study. As can be seen in Figure 6-2, interviewee (C1-I1) said, *"The group discussion out of that face-to-face meeting brought our understanding to a whole new level of how we could make it even simpler",* so this was coded as 'Realisation of a Better Design' first-order code, which led to this code being aggregated the 'discovering customer insight' second-order code.

6.4.2.3 Coding of the Insight Process

The first-order codes were coded as activities and comments. The aggregation of the first-order codes into five second-order codes created process steps the team were undertaking with the associated inputs (predecessors) and subsequent outputs (successors) for the step. Table 6-9 shows the first-order codes (2nd column) and the associated representative quote with the aggregated second-order codes (1st column). The second-order codes (process

steps) were analysed to extract the input, action, and output; the result of this analysis is shown in Table 6-10. For example, the input 'ideas, concepts' was used in the 'design meetings' action, the output to this was 'New perspectives, evaluations, creation of lower-level needs and insights'; the example quote to validate this process step was *"I think that talking to customers has been the most valuable part of the development project process, I think that actually talking to the surgeon, seeing what they want in their perspective on things is really, really critical and their perspective is different than ours"*(C1-I4). This quote confirmed that the design meeting was when the team talked to the customer and used prototypes to demonstrate ideas, which led to new perspectives.

Figure 6-2: NVivo Screenshot Showing First-Order Coding



Source: Author

Table 6-9: Analysis: Second- and First-Order Coding of Practices

Second-Order Codes	First-Order Codes	Data Sources		Representative Quotes	Source Reference
		Interview	Document		
Understanding the Unmet Need	Initial problem understanding	•	•	*It's kind of interesting because the spine and pelvis, you know that top level one is really a business need.*	C1-I3
				Many of these technologies currently require considerable input and thought on behalf of the surgeon. The aim of enabling technologies should be to attain automation and thus reduce cognitive overload – take the thinking out of the theatre, our key to success. This may include the removal of mundane tasks or reducing less critical ones.	C1-D1, p.4
	Market driven unmet need	•		*We knew that they've gone into the market, talked about spinal pelvic tilt, generated a conversation, caused a problem for us. And whether we like it or not, there's now an unmet need.*	C1-I1
	Problem statement process	•	•	*The problem statement drove our research. What are we doing? What demographic are we going after? What is the consumer's point of view? Why are they interested in this? What's the price value? So really defining what the project was without actually doing any design work at all.*	C1-I2
				Accurate, patient-specific, 3D planning for patients will allow surgeons to operate with confidence.	C1-D1, p.6
	Questioning the teams understanding of the needs	•		*What are you trying to do with this product? Why are you doing this? What user need are you trying to address?*	C1-I1
	Project innovativeness	•		*That solution exists in the world. It doesn't exist for us, but it does exist in the world and our customers are familiar with that concept. They've seen it before somewhere else. But within that overall concept, there's innovative features that have not been seen which would delight the customer.*	C1-I3

Second-Order Codes	First-Order Codes	Data Sources		Representative Quotes	Source Reference
		Interview	Document		
	Technology solution and technical language	•	•	*Sometimes you've already been given the technology, the direction of technology. And you're having a conversation and there is an insight that that surgeon gives you that they don't realise, and that just pings something in your own mind. I could get around it with that technology.*	C1-I2
				Surgeon wants the application to provide a recommended (target) acetabular orientation to provide balanced cup coverage and avoid implant on implant impingement.	C1-D3, p.2
Engaging with Customers	Gathering customer inputs and opinions	•		*The surgeon group, we're working with 14 surgeons across the world who are high volume and really know their stuff. A great group and really cross-sectional as well. We've got China, Japan, Australia, Europe, US.*	C1-I2
	Communication with customers	•		*We've been having a lot of surgeon design team meetings. We have a surgeon design team and we've been corresponding with them pretty regularly, at least monthly meetings, quite a few emails coming out asking their perspective on things.*	C1-I4
	Listening to customer	•		*The doers state I want to drag and drop my two x-rays, make my landmarks and get my outputs. But I don't care about the bit in the middle. Don't tell me about it. So, for them all that information needs to be round the back and out of the way. They want to be nice and clean page, whereas the real thinkers, they want to be able to access that information. So, you've got a real dichotomy like how you show somebody the same screen and not overcomplicate it for this person and not under complicated for this person.*	C1-I2
	Key People involved with the Insight	•		*Bioengineering, IDHF, marketing. Sometimes our software developer comes on if there's software specific questions, and then sometimes our project manager. The bioengineer, he's usually leading the conversation.*	C1-I4
	Design discussions	•		*Product development is the collaboration and the combined brainpower of your team and not just the individual.*	C1-I1

Second-Order Codes	First-Order Codes	Data Sources		Representative Quotes	Source Reference
		Interview	Document		
	Benefits and values	•	•	*We had a conversation, a bunch of conversations with a surgeon and they said that this is confusing and it's not value adding.*	C1-I4
				Reduced cognitive load enabling technologies will provide increased accuracy and efficacy of planning to drive intra-op execution technologies without adding time to surgery.	C1-D1, p.10
Understanding the Customer Needs	Balancing needs with customers	•		*Then sometimes we get to balance stuff. I go back to the surgeon group between calls and say - Hey, guys, you gave us ten things. Six of them are dead easy. We'll get them done tomorrow. We know how we're going to do it. Of the four other the things, three of them strike, three of them are okay but going to take a month. The last one we're just not sure about because it's a really big problem, it actually means changing the whole process. How important is that to you?*	C1-I2
	Design - user, human-centred, empathic, thinking	•		*As the programme evolved and as we learned. But that empathy part, what our users needed and how they were doing things.*	C1-I1
	Differing customer needs	•		*One of our biggest problems, you've got different spectrums of surgeons and you've got real thinkers and doers.*	C1-I2
	Dynamic and evolving needs	•		*Understand some user needs, build something based on those user needs and then use that new prototype as a starting point for follow-on conversation.*	C1-I3
	Hierarchy of needs	•		*Hierarchy isn't that you can probably draw a lovely diagram of them. We see a tree that kind of describes needs.*	C1-I3
	Iterating Needs	•	•	*But you have to start somewhere. So, you start. You prototype, you evaluate, you refine, you evaluate, you refine.*	C1-I1
				Revisions of RTM and TPP.	C1-D3 C1-D1
	Reason for needs	•		*I guess I draw a distinction, a loose distinction between what the individual, the outcome that the individual wants to achieve, from how they achieve it.*	C1-I2

Second-Order Codes	First-Order Codes	Data Sources		Representative Quotes	Source Reference
		Interview	Document		
	Unarticulated, tacit, latent, unconscious	•		*What people do and what people say they do are often, there are two totally different things. Yes, they can articulate why they need things or why they do things, but they don't really think about it.*	C1-I1
	Customer perspectives	•		*They want to understand exactly how the decisions are being made.*	C1-I3
	Exploring the context	•		*We spent a day or two in the operating room with all, close to all 24 of our international (surgeon) design team and just videoed them.*	C1-I1
	Finding the right question to ask	•		*What's the question you're asking? What do you need answered? And does it require a surgeon and a cadaver?*	C1-I1
Iterative Design and Development	Complexity of features	•	•	*We added something to add an extra dimension that just complicated matters. And it was really, it was a really small thing, but it complicated everything.*	C1-I2
	Customer reaction to prototypes	•	•	*The project team had a load of user needs and we put them into a prototype that seemingly once a quarter or once a month, I'd put the prototype in front of the surgeons and let them react to it.*	C1-I2
				Figma Software prototyping.	C1-D4
	Design issues with the context of use	•	•	*We're working on a product that the engineers would mess with, interact with that on their table, their desk, and it was designed perfectly well. Guess what you put in front of a user and its actual environment.*	C1-I1
				Usability Validation Lab.	C1-D3
	Finding the MVP	•		*I think falling into a bit of a trap of some MVP and we waste a lot of energy trying to come up with that.*	C1-I3
	Iteration of understanding	•		*And each of those really has been driven through the iterative cycle with the surgeons and showing them solutions and understanding with those solutions, working on, and that whole process.*	C1-I3

Second-Order Codes	First-Order Codes	Data Sources		Representative Quotes	Source Reference
		Interview	Document		
	Prototype testing	•	•	*Testing early and often with low fidelity prototypes at low risk and high reward was a big part.* Figma Software prototyping.	C1-I1 C1-D4
Discovering Customer Insights	Discovering the Insight	•		*Well defined kind of eureka moment with one specific, kind of like core thing. We had a specific challenge in terms of how femoral neck version is represented in our technology. So, we had identified through conversation that surgeons wanted a certain output, implant impingement information. But that's, we realised internally that that's dependent on femoral neck version is something that you cannot measure within the system.*	C1-I3
	Lots of ahas	•		*There's been a lot of aha moments because as you're trying to solve how you take this complex piece and deliver it in a nice, neat way. There were, for instance, lots of aha moments with UI and UX.*	C1-I2
	Realisation of a better design	•		*The group discussion out of that face-to-face meeting brought our understanding to a whole new level of how we couldn't make it even simpler liked what they saw. We could have stopped there. But, as the development experts, saw how we could make it one more step easier and intuitive and we made a change.*	C1-I1
	Solution	•		*It felt it's really long journey, you know, identifying all of these features that we wanted in the advanced type and then slowly realising that actually they weren't useful and didn't really work and were confusing and causing more problems than they solved and then eventually coming right back to this basic kind of solution.*	C1-I3
	Finding insights	•		*So that there's little insights that have built up to be the actual product as it is, but the need was, and the insight was sort of more just general. We need a tool to help us place the cup. There's lots of needs and insights as you work through it, that actually the complexity of doing that needs to be solved and these little problem stages.*	C1-I3

Source: Author

6.4.3 The Insight Process

The front end of product innovation, as described by the Marketing Director (C1-I2), relied on using software prototyping to understand customer needs and discover customer insight. This was achieved through multi-touchpoints with customers and the internal team using informal conversations, design meetings, and focus groups. The practice employed to uncover the customer needs was principally using software UX/UI prototyping to determine how the application would function and test the features. The process steps are presented in Table 6-10; the table shows each top-level process step, the sub-step with associated input/action/output practice, and a representative quote. The top-level process steps were:

1. Understanding the unmet need: this involved refining the need and creating the Target Product Profile document.
2. Engaging with Customers: This revealed new perspectives, lower-level needs, and insights.
3. Deeper Understanding: each uncovered need and discovered insight was evaluated. This step led to a further refinement of the customer needs.
4. Design Iteration: this consisted of creating the prototype and testing the functionality and features with a customer through multiple iterations.

After multi-design iterations, the customer insight was discovered: the customers did not need the level of accuracy that the software afforded to make the correct clinical decision. This insight led to the software system being simplified.

Figure 6-3 describes the process step - the associated inputs, actions, and outputs. For instance, the first process step, 'understanding the unmet need', involves taking the input of the unmet need and then conducting an informal discussion with users (surgeons). The output is a refined understanding of the unmet need. Though the figure shows a linear flow with iterations, it has been reported (Koen *et al.*, 2001) that the FEI can be fuzzy. For example, there is a strong interplay between engaging customers and design iterations, as will be explained in the discussion below. The iterative circles are important as new information is gathered and understanding of the problem increases, which leads to refinement. It was not possible to show a clear chronology (timeline) with the data that had been captured.

The following five sub-sections expand and provide more detailed context to the summary in Table 6-10: The Insight Moment Process Steps. In sum, customer insight was discovered through an iterative process of creativity, design, prototyping, and evaluation, leading to a deeper understanding of the problems faced by the customer.

Table 6-10: The Insight Moment Process Steps

Process Step	Input	Action	Output	Representative Quotes	Source Data
Project Strategy	Business Need	Informal discussions with customers	Defined unmet clincal need	*The unmet need drove the requirement to talk. We then make an effort to go and speak to other surgeons. And I think at that point, we don't necessarily do market research. We don't go and employ somebody to go in ask surgeons. To begin with, we go in, ask our own people. So people who we work with on a daily basis, to surgeons who are part of a team, to ask them about this, about this unmet need.*	C1-I2
Understanding the Unmet Need	Defined unmet clinical need	Focus groups	Refined understanding of unmet clinical need and business need	*We then start to use more focus groups surgeons, there that can be a cadence of different meetings that I attend.*	C1-I2
	Refined unmet need	Market research	Target Product Profile document	*Enabling technology, which is templating, 3-D planning 2D to 3D, we wrote a TPP that covered all of those things.*	C1-I2
Engaging with Customers	Target Product Profile document	Virtual meetings to discuss unmet need	Ideas, Prototype concepts	*You can do virtual meetings with a digital application that they're going to be looking at on a computer screen in any way, enabled by that, they don't need to hold a metal part in their hand.*	C1-I1
	Ideas, Prototype concepts	Design meetings at multiple stages in the process	Uncovered customer needs	*We've been having a lot of surgeon design team meetings. We have a surgeon design team and we've been corresponding with them pretty regularly, at least monthly meetings, quite a few emails coming out asking for their perspective on things.*	C1-I4
	Ideas, Prototype concepts	Customer discussions	Uncovered customer needs	*I think that talking to customers has been the most valuable part of the development project process, I think that actually talking to the surgeon, seeing what they want in their perspective on things is really, really critical and their perspective is different from ours.*	C1-I4

Process Step	Input	Action	Output	Representative Quotes	Source Data
Understanding the Customer Needs	Uncovered customer needs	Observation	Revised customer needs	*We spent a day or two in the operating room with all, close to all 24 of our international design team and just videoed them.*	C1-I1
	Uncovered customer needs	Identifying the customer	Revised customer needs	*The customer is the radiographer because you need this protocol to suit the radiographer because the radiographer is important in getting the results.*	C1-I4
	Revised customer needs	Uncovering the customer needs	Deeper understanding of the customer New perspectives, evaluations, creation of lower-level needs and insights	*We just ask the question and open it up to the floor and say, What are your thoughts? And I think that that's really valuable to kind of have an open discussion forum.*	C1-I4
	List of Customer needs in Requirements Traceability Matrix	Needs Assessment	Deeper understanding of the customer New perspectives, evaluations, creation of lower-level needs and insights	*Meticulously scrutinising what's the user need? What are we doing? What's what is that question we need to answer?.*	C1-I1
	List of Customer needs in Requirements Traceability Matrix	Needs Assessment	Revised list of Customer needs in Requirements Traceability Matrix	*The starting point for that cyclical process of the design iterations. Understanding what the base need or insight is for that project.*	C1-I1

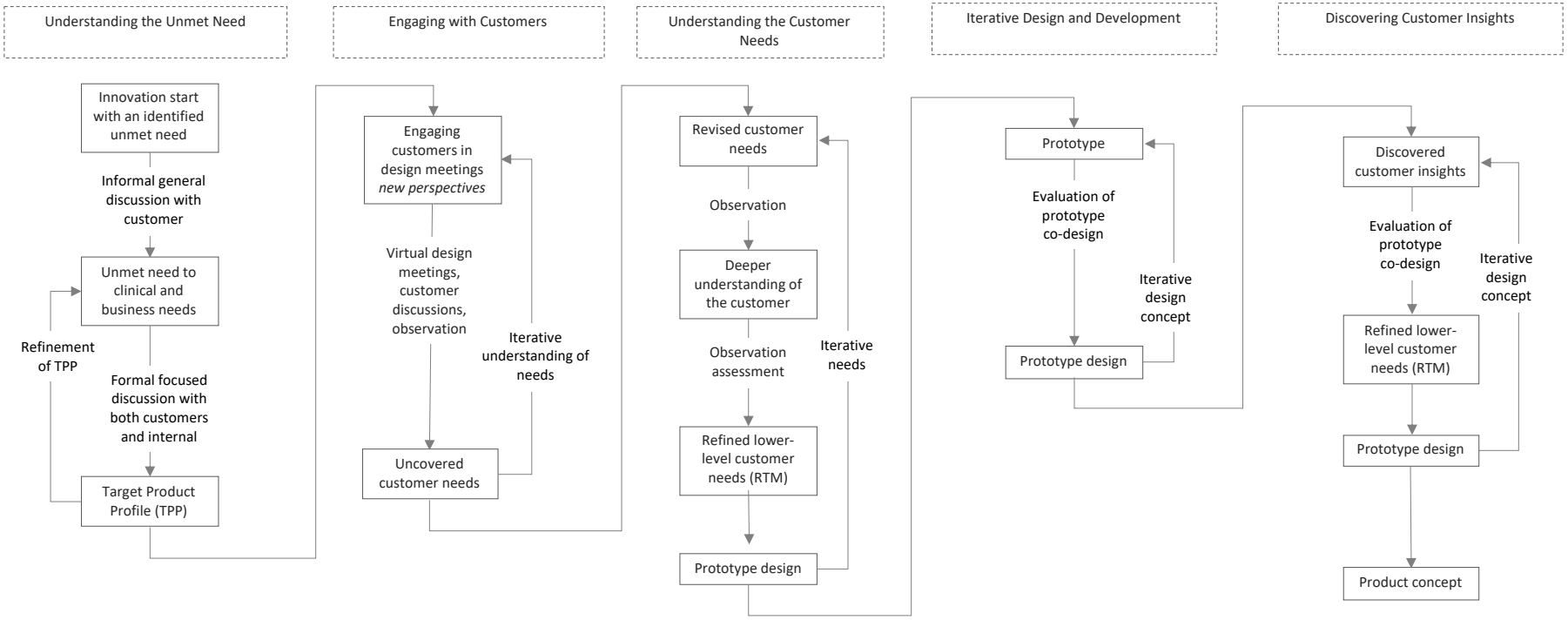
Process Step	Input	Action	Output	Representative Quotes	Source Data
	List of Customer needs in Requirements Traceability Matrix	Needs Assessement	Revised list of Customer needs in Requirements Traceability Matrix	*Hierarchy isn't that you can probably draw a lovely diagram of them. We have a tree that kind of describes our needs, at the top level, there's a need, which for us is to understand spider pelvic mobility. And then below that are more detailed needs and below each of them, are more detailed needs and below each of them, are more detailed needs.*	C1-I3
	Requirements Traceability Matrix and prototype designs iteration	Design meeting	Revised list of Customer needs in Requirements Traceability Matrix	*Understand some user needs, build something based on those user needs and then use that new prototype as a starting point for follow-up conversation and yeah, you do sometimes go around in a circle.*	C1-I3
	Requirements Traceability Matrix and prototype designs iteration	Design meeting	Revised list of Customer needs in Requirements Traceability Matrix	*I think it's probably even in a good three or four occasions where we've designed and developed something, put it in front of the group and it's fallen flat on its face.*	C1-I2
Iterative Design and Development	Design ideas and concepts	Evaluation with internal team	Revised ideas and concepts	*We meet regularly, and we put forward those proposals. As we're putting forward proposals in the back of my mind, we're kind of cognisant of the need to be feasible from a software perspective. And within the constraints of the software that you were adding into the chain and that adds some constraints.*	C1-I3
	Design ideas and concepts	Evaluation with internal team	Revised ideas and concepts	*Many times, it doesn't require a medical background to evaluate what we need evaluated. Often, we don't give ourselves credit as being the answer means the system matter experts, the medical device developers. We are key opinion leaders as well in our in our own right.*	C1-I1
	Prototyping	Evaluation of prototype with surgeon team	Revised prototype, iterative loop	*You prototype, you evaluate, you refine, you evaluate, you refine, you evaluate, and then you get to a point where there's nothing left to refine because you've solved all the issues.*	C1-I1

Process Step	Input	Action	Output	Representative Quotes	Source Data
	Prototyping	Evaluation of prototype with surgeon team	Revised prototype, iterative loop	*There's been lots of little iterations and as you kind of take the surgeons through this journey of what we're trying to achieve, they've been really great at going, 'OK, that's too complex. Let's narrow it down.*	C1-I2
	Bookend prototypes	Co-creation with surgeon team	Revised prototype and features, iterative loop	*We took them kind of bookend prototypes, and I'm always a bit conscious that it feels like wherever you draw the two points, they're always going to pick the middle. If you say, do you want A or B? They always say somewhere between the two C. That way your kind of almost making the decision yourself, by the way you define the end points. But that cycle, I think of giving them a couple of options and then talking through what they like and don't like and co-creating a new solution has been something we've done over and over and over again across all the different features.*	C1-I3
	Prototyping	Evaluation of prototype with surgeon team	Revised prototype, iterative loop	*It felt it's a really long journey, you know, identifying all of these features that we wanted in the advanced and then slowly realising that actually they weren't useful and didn't really work and were confusing and causing more problems than they solved and then eventually coming right back to this basic kind of solution.*	C1-I3
	Prototyping	Evaluation of prototype with surgeon team	Revised prototype, iterative loop	*Some features that probably haven't changed from day one. You know, they've always been present, and they've remained sticky.*	C1-I3
	Prototyping	Evaluation of prototype with surgeon team	Revised prototype, iterative loop	*I'd put the prototype in front of the surgeons and let them react to it. They would say things that they liked, things that weren't the things that didn't work.*	C1-I1
Discovering Customer Insights	Prototyping	Evaluation of prototype with surgeon team	Discovering lower-level insights	*There were lots of aha moments because as you're trying to solve how you take this complex piece and deliver it in a nice, neat way. There were, for instance, lots of aha moments with UI and UX.*	C1-I2

Process Step	Input	Action	Output	Representative Quotes	Source Data
	Prototyping	Evaluation of prototype with surgeon team	Discovering lower-level insights	*Well defined eureka moment with one specific, kind of like core thing. We had a specific challenge in terms of how femoral neck version is represented in our technology. So, we had identified through conversation that surgeons wanted a certain output, implant impingement information. But what we realised internally is that that's dependent on femoral neck version and is something that you cannot measure within the system.*	C1-I3
	Prototyping	Evaluation of prototype with surgeon team	Discovering lower-level insights	*The insight they didn't really care about the specific number, because they knew they weren't going to be accurate, so they didn't really care whether it was 10 or 11. What they really cared about was just crudely putting it into a bucket.*	C1-I3
	Prototyping	Evaluation of prototype with surgeon team	Discovering lower-level insights	*But the group discussion out of that face-to-face meeting brought our understanding to a whole new level of how we could make it even simpler.*	C1-I1
	Prototyping	Evaluation of prototype with surgeon team	Discovering lower-level insights	*Insight occurs when somebody says something and it's usually small details like that that's really important. We need to make sure that we do something about that.*	C1-I4
	Prototyping	Evaluation of prototype with surgeon team	Discovering lower-level insights	*So that there's little insights that have built up to be the actual product as it is, but the need was, and the insight was sort of more just general - 'We need a tool to help us place the cup'. There's lots of needs and insights as you work through it and actually the complexity of doing that needs to be solved at these little problem stages.*	C1-I3

Source: Author

Figure 6-3: Insight Discovery Process from Spark



Source: Author

6.4.3.1 Project Strategy

In discussing the case study project, the Marketing Director described that a business need initially drove the project. Competitors already had software technologies that addressed the need; this competitive situation caused the company problems with answering enquiries from surgeons with a growing interest in the issue of pelvic tilt. However, he was not sure if there was also an unmet clinical need or only a business need. He spoke about that saying only time will tell – "*And whether we like it or not, there's now an unmet need. You know, so whether it's a true unmet need or not is sometimes always, you know, a discussion point*" (CI-I2). The unmet need is seen as the fundamental problem statement that provides the context of the market research and subsequent need gathering and insight discovery (C1-D5). In this case, identifying the unmet need represents the initiation of the front end activities. The Marketing Director (C1-I2) continued to explain:

> *"Generally, from that point of view, we make an effort to go and speak to other surgeons. And at that point, we don't necessarily do market research. Now, we need to employ someone to go in and ask surgeons. To begin with, we go in and ask our people. So, people who we work with on a daily basis, to surgeons who are part of a team, so you might say, oh, you know what? I've got a meeting coming up, and I've got 20 surgeons in a room; I'll put 15 minutes in the diary to ask them about this unmet need."*

6.4.3.2 Understanding the Unmet Need

For this case study, the unmet need was acetabular cup placement and positioning, a known problem within the industry for many years (Hirata *et al.*, 2013). Additionally, pelvic tilt has recently been discovered as the underlying issue with cup placement that could cause hip dislocation. Therefore, the innovation team was formed to investigate the unmet need for cup position with reference to pelvic tilt; pelvic tilt is explained in Figure 6-5. The TPP document (C1-D1) stated the clinical need, 'The integrity of successful Total Joint Replacement (TJR) is dependent on several technical factors, including appropriate sizing, alignment of components, ligamentous balance, and mechanical alignment of the joint in relation to pre-operative position, contra-lateral position, and the lower spine. The principles of TJR are developed from basic biomechanical principles.

Without the benefit of Enabling Technologies, TJRs are generally performed in isolation with mainly manual instrumenting assumptions gained from previous surgeries and training by individual surgeons. This may produce varied surgical results.

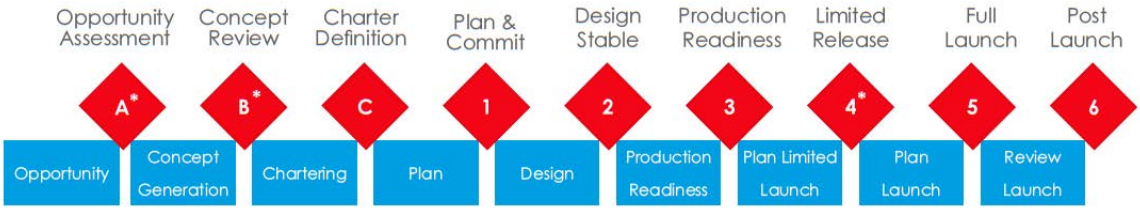
Before assembling a team to investigate the unmet need, the marketing function started initial informal fact-finding with surgeons:

> *"You're just asking them about the problem. Do you think that is a problem? Is that something that you don't have an answer to? You know, is it worth investing in finding an answer to that problem? And, how big is the market if we got there? So, because that's the next stage, once you start finding out if something is an unmet need and is an issue, then the next part is - How big of an issue is it? What are the implications of that issue? Is it something that's adding time and money to surgery? Is it something that's reducing or increasing the revision rate of our implants?" (C1-I2)*

After this, a team of four people were co-opted to look at the unmet need; budget and headcount were assigned. In this case study, the innovation team comprised marketing, industrial design and two engineers from product development.

The company's stage-gate process, known as Cadence (refer to Figure 6-4, C1-D5), does not specify the activities that must be conducted and only focuses on the output documents. The front end gates in the process are gates A and B, and the FEI finished with Gate C (charter), at which point the project enters the NPD phase of development. Gate A (C1-D4) is described as the 'Opportunity Assessment Review Definition, ' which is an assessment of the opportunity and determination of whether the business should pursue this project/idea/concept. Gate B (C1-D4) is described as the 'Concept Review Definition'. It is the review of the potential clinical and commercial benefits of the concept with the identified opportunity and determination of whether the project should proceed to prioritisation and charter. Each gate consisted of a series of questions to be answered by the innovation team.

Figure 6-4: Cadence Stage-Gate Process

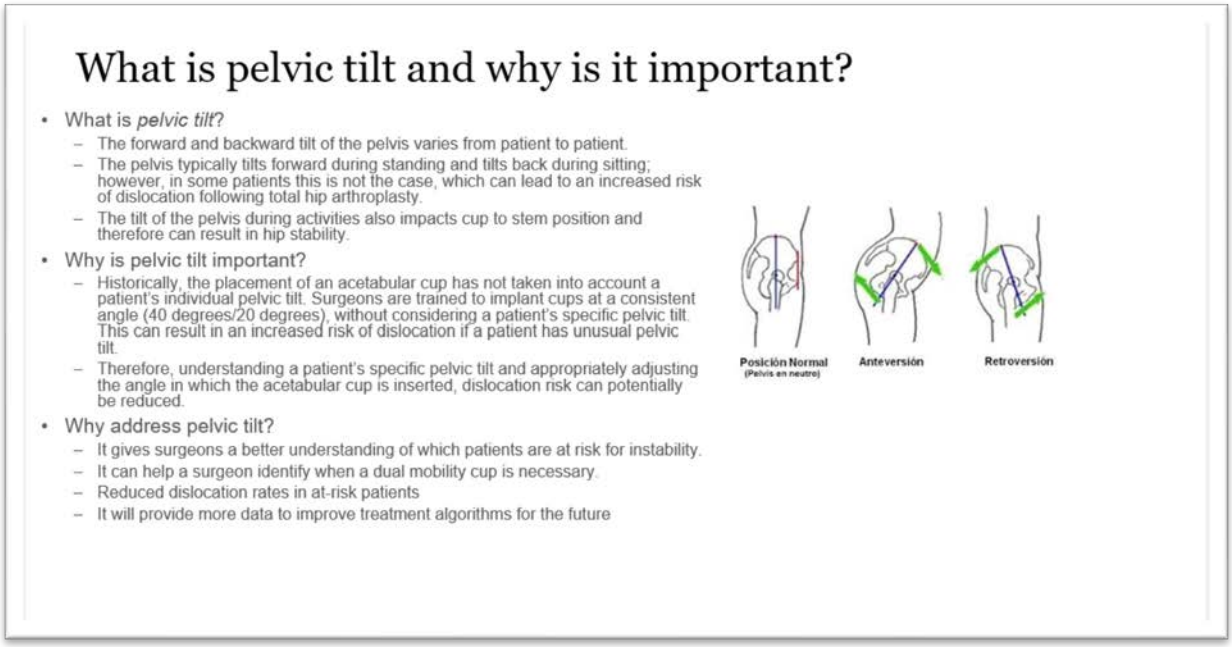


Source: Cadence stage-gate guidance v11 (C1-D5)

Cadence does not specify the activities that should be conducted in the FEI. It only prescribes the questions that need to be answered (e.g., the outputs); this allows the innovation team to choose how to explore the FEI. At Gate A, a document known as the Target Product Profile (TPP) is created. The TPP contains the major themes of the innovation project – unmet need, clinical need, preliminary business case, etc. The team used the information within the TPP and delved into it to better understand the unmet needs. They used Post-it notes to scribble on and sketch various ideas that they were considering, "that act of an idea on a P*ost-it and slapping it on the wall gets it out of your head and frees up your creative space"* (C1-I1). This step of pulling out all the team's ideas was seen as critical so that the team could see all the ideas. The post-it notes were clustered to create a picture of the problem, the user needs, and potential solutions.

The technology direction to meet this unmet need was already in development. Hip planning software is well known in the industry, but it was the execution of how the software application would function that drove the innovation. For example, the Lead Engineer explained, "*The solution exists in the world. It doesn't exist for us, but it does exist in the world, and our customers are familiar with that concept. They've seen it before somewhere else. But within that overall concept, there's which there are innovative features that have not been seen which would delight the customer"* (C1-I3).

Figure 6-5: PowerPoint Slide Extract from the Target Product Profile



Source: Front end slide presentation (C1-D2)

6.4.3.3 Engaging with Customers

The company typically develops metal and plastic hip and knee medical devices. In contrast, this case study was a software development project that departed from the traditional product development process. This enabled the team to approach the FEI differently for this project when engaging customers. They were able to have more frequent design meetings, use video conferencing technologies to demonstrate the software concepts and quickly explore surgeon perspectives. They were also able to talk about software version releases, investigating what the first release could embody; *"that's the real difference that really changes how we and the engineers have our conversation with the surgeons"* (C1-I2). Also, email was used extensively with the surgeon design team to continuously ask for their viewpoints on screenshots and workflows to obtain faster feedback. They also found that surgeons had different needs when presented with the concepts. Empathy with users was a common thread, *"that empathy part, what the users need and how they were doing things, it drove new user needs"* (C1-I1).

The two surgeon types uncovered were termed 'real thinkers' and 'doers'. The doers just wanted to get the job done, *"' I want to drag and drop my two x-rays, make landmarks, and get my outputs. But I don't care about the bit in the middle. Don't tell me about it. So, for them, all that information needs to be around the back and out of the way. They want*

to be nice and clean page" (C1-I2). In contrast, real thinkers wanted to see the data and calculations the software was making. These two differing needs caused the innovation team a significant issue with how they present the data so that it is not too over-complicated for the doers and does not provide too little information for the real thinkers.

To further understand the needs, the team were required to have a purposeful engagement with the user population. The team's goal was to gain a greater appreciation through this interaction. The team emphasised that testing is crucial once the concepts are created, *"the importance of testing early and often because that great idea you had may not be a great idea for everyone else. So, you put that great idea in front of people, and they react to it differently, and you can get fingers and branches off that idea. Yeah, that's the great part about collaboration within these four walls when we run brainstorms. Your idea is individually presented to the group and allows that collaboration and building of ideas"* (C1-I1). Once the ideas had been through internal testing, the team started putting the concepts in front of the users and obtaining their feedback. This cyclical process of design iterations from understanding the unmet need and exploring the various paths the team could take significantly impacts the customer needs; *"If you look back at those original user needs, many of them probably haven't been met or have been modified so much that they're not the same anymore"* (C1-I3). This concepting, prototyping, and testing process produced insights that evolved into needs. This showed the cyclical nature of the FEI; there was a clear interplay from the creation of the ideas and prototypes and the engagement of customers with the prototypes to a subsequent design iteration.

Since software development provides rapid prototyping ability, the team could explore each concept iteration monthly with the surgeon design team, giving iterations fast feedback. *"I'd put the prototype in front of the surgeons and let them react to it. They would say things that they liked, things that worked and things that didn't work. 'Oh, what if I did this? What if I did that?'"* (C1-I1). With traditional product development, each design iteration takes at least three months due to the time it takes to produce the computer-assisted design (CAD) layouts, manufacture prototypes, and bring the surgeons to one place to perform the mock surgeries.

The team frequently gathered to discuss the project. There were two weekly design meetings when the team got together to review the needs and any feedback they received

and investigate how the UX/IU was developing. Changes to the concept were evaluated with an eye on the impact on the software, timeline, and budget. Feedback was assessed on its importance. However, the reason for its importance was questioned as there was always conflicting input from customers, both internal and external. A lot of the discussion was based around the software UI/UX look and feel. The underlying software technology was built early in the process and did not require significant modifications. The workflows presented to the users were the critical problems, and this was when the mini-aha moments came in (which will be discussed later).

Talking to customers was reported as the most valuable activity in the process, as was understanding their perspectives and how they differ from the innovation team's perspective on the problem. For example, the Industrial Designer (C1-I1) stated that he questioned, *"What are we doing? What's that question we need to answer? What's the question you're asking? What do you need answering?".* Engaging with the customers led to a deeper understanding of the problem and evolving needs and insights.

6.4.3.4 Understanding the Customer Needs

The participants all spoke about how the initial customer needs evolved when either new insights occurred or when developing and testing the concept. They would understand some needs, build a prototype, and then use that prototype iteration to uncover the next level of needs and discover newer customer insights. It was also confirmed that some needs changed significantly, and others never changed from day one*, "If you look back at those original user needs, many of them probably haven't been met or have been modified so much that they're not the same anymore"* (C1-I1*).* In contrast, some have always been constant, *"they've always been present, and they've remained sticky"* (C1-I3). Furthermore, *"a few of them may have been canned, but I would speculate that the majority of them are still solid and accurate. What evolves is your understanding of that user need and how to make it into an actionable design"* (C1-I1). The evolving needs were driven by the iterative cycle by gathering the customer reactions, *"if you understand these needs perfectly, you would have designed it perfectly in the first place. And the fact it tells you that you've misunderstood the needs and you are finding them as you go"* (C1-I3). Needs evolution occurred when they learnt more about the problem, the customer, and the customer's context.

Low-fidelity prototypes were utilised to explore the needs with in-house staff, *"you have an idea, you don't need to wait till you have a prototype with a surgeon design team, sitting in a room with a cadaver to learn how you can make it better. Walking it around the company building and showing it to people who are not part of the development process gives you loads of information for refining it and making it better."* (C1-I1). The iterative design approach was primarily based on the rapid prototype ability of the software, "*You prototype, you evaluate, you refine, you evaluate, you refine your prototype, and then you get to a point where there's nothing left to refine because you've solved all the issues"* (C1-I1). The iterative approach also required the team to ensure that they led the surgeons through how the prototype was developed alongside the evolving needs. However, with lots of minor iterations, the unmet need can get lost. It was found that the evolving needs shifted the unmet needs a little bit at a time. It could lead to the product becoming too complex, leading to feature creep, so they checked back throughout the journey, asking themselves, *"What are we trying to achieve here?*" (C1-I2). Ultimately, it was recognised that at the start of the FEI, the exploratory process of evolving needs affords opportunities for new insights that become more refined needs.

Lower-level insights were discovered when the product's design began to emerge, leading to new needs. The R&D Lead Engineer (c1-I3) explained that *"little insights have built up to be the actual product as it is… There are lots of needs and insights as you work through the complexity that has to be solved".* Furthermore, this process that led to newer needs was described as an increase in needs, *"At the top level, there's a need, which for us is to understand spinal pelvic mobility. And then below that are more detailed needs and below each of them, a more detailed needs and below each of them, a more detailed need"* (C1-I3). A couple of respondents touched on the hierarchy of needs. It was described as a tree of needs, with the unmet needs at the top and more detailed needs that can be traced up to the unmet needs.

Negative feedback was also an important aspect. The Lead R&D Engineer (C1-I3) reported that the prototype worked well when demonstrated to other marketers and engineers, but they received an adverse reaction when it was presented to the surgeon team. When showing the prototype, the Marketing Director said: *"I think it's probably a good three or four occasions where we've designed and developed something, put it in front of the group, and it's fallen flat on its face. We have gone, 'Oh, that works,' then we*

put it in front of the surgeon group who say, 'I don't get what you're trying to give us here. It doesn't make any sense. We get what spinal pelvic tilt is, but we don't understand what you've done here" (C1-I2). This feedback helped uncover the unarticulated needs. Furthermore, the design meetings, which comprised both the innovation team and the surgeon design team, facilitated a lot of discussion about customer needs and sparked a lot of problem-solving and discovery of new insights:

> *"We just ask the question and open it up to the floor and say, 'What are your thoughts?'. And I think that it's really valuable to have an open discussion forum with all these surgeons. They can then hear each other and each other's opinions. And so, if one person says, 'I want it green', the other says, 'It shouldn't be green because of this', and then another person says, 'Well, it should be blue because of this'. And I think that that's all really valuable is to have them interact, hear how they interact. And you can just learn a lot from all across the world, the different cultures of different countries, all of the different experiences these surgeons have" (C1-I4).*

The Marketing Director pointed out that customer needs must be balanced with each other, and compromises are essential. When a surgeon design team suggests new needs or offers modifications, the innovation team must evaluate each piece of feedback on its own and within the whole product context. The majority are easy to incorporate and address. However, some needs require a more significant change. These generate a discussion with the innovation team and surgeon design group by asking questions and exploring the options,

> *"How important is that to you? That's my job, so I say, are you going to still use this product if I don't do that? Or, you know what, if we found a different way. So, they might come back and go, but the way you've got it right now, it's not going to work. So, if you can find a better way that's not going to take months, then we'll have a look at it. So sometimes your answer to the unmet need is not necessarily the thing you always want to do. It's a balance of, well, what do I want to do? What can we get done with the money, the resources, the time that we've got?" (C1-I2)*

In an example of deeper understanding, the Lead R&D engineer gave the example of the scorecard, *"we came up with the idea of a scorecard. I don't know whether this is us being slow to understand what the surgeons wanted. You know, in hindsight, I don't know if they're actually asking for this all along. We finally heard what they were asking for. They weren't really clear what they wanted, and we kind of organically discovered the solution, but we've ended up with this idea of kind of a grade card"* (C1-I3).

A deeper understanding enabled the team to discover the insights that drove the product to a higher level of success. Evolving needs through the FEI is an iterative process of exploration with customers (in this case, the surgeon design team) through discussions, prototype demonstrations, and internal company expertise that provide opportunities for insight discovery. Conversely, new needs can also adversely affect the development with feature creep or pursuing design pathways that lead to dead-ends. However, this is valuable for the team to gain deep knowledge about the customer.

6.4.3.5 Iterative Design and Development

The base software algorithm was already built before the team started the FEI. So, the team primarily focused on prototyping the software's user interface and user experience (UX/IU). As such, the team had to rapidly refine what information was to be shown to the surgeon when planning the cup position. Therefore, quick iteration of the prototype was crucial to their success. Design iterations went together with a deeper understanding and evolving needs.

The design iteration process first involved from understanding the surgical planning process to the optimal cup position. Next, the team produces a prototype UI using the Figma software to model their design concept; see Figure 6-6 and

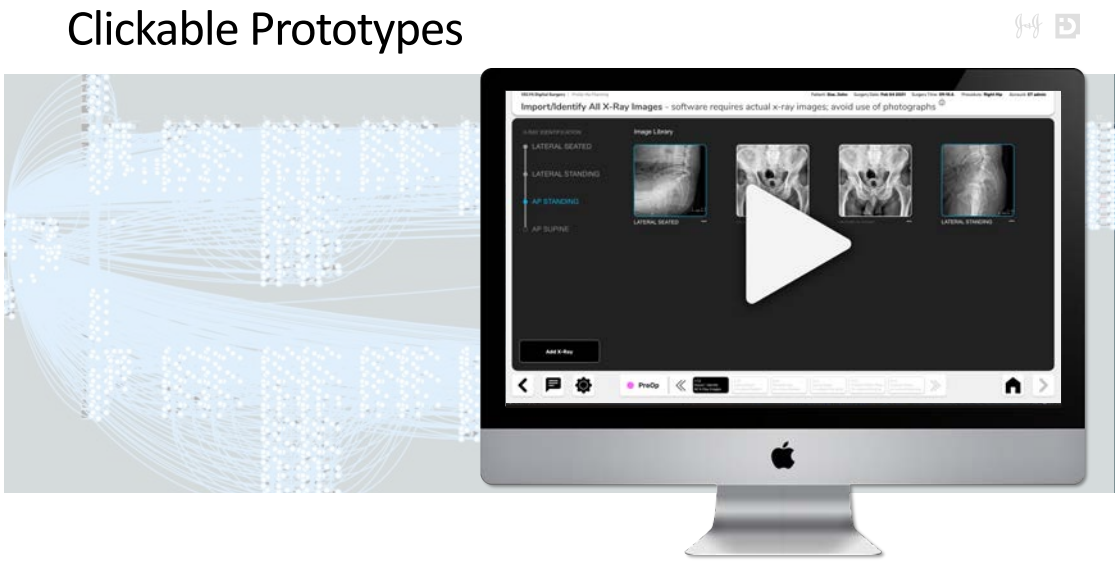
Figure 6-7 below for a screenshot of the prototype. These initial prototypes would then be demonstrated to the surgeon design team. After each demonstration, the team had a more refined understanding of the customer needs and was able to discover insights. For example, the Industrial Designer described that the initial prototypes were developed using in-house expertise, "*we're working on a product that the engineers would mess with, interact with that on their table, their desk, and it was designed perfectly well. Guess what? You put it in front of a user, and its actual environment didn't meet their needs*". This internal and external testing of ideas and concepts allowed the team to advance their

understanding. The Marketing Director (C1-I2) explained, "*The project team had a load of user needs. We put them into a prototype that seemingly once a quarter or once a month. Then, I'd put the prototype in front of the surgeons and let them react to it".*

However, the team occasionally added too many features and functions, making the product too complex. They had to undergo an iterative process to learn what was good enough to be the MVP. They found out that not all needs are equally important; sometimes, a more in-depth understanding is required. It was recognised that a product needs to be made up of a list of needs it meets or does not meet. There is balance and compromise between the needs. The R&D Lead Engineer explained that upper and lower limits exist with all types of engineering; however, in product development, *"there is no upper limit because you can always deliver more*" (C1-I3) and that the lower minimal limit is only the essential factor. However, he pointed out that there is a catch with the MVP theory, as it is challenging to find the bottom (minimum) when considering needs. With the Cadence process, there is a customer need generation phase, then a distinct design phase. In practice, the R&D Lead Engineer does not think this is the process, *"To try and sit down and without doing any development work, identify all the user needs. I don't think it is possible. And even if it is possible, I think it would be massively inefficient"*(C1-I3). He suggested that the team uncover some user needs, build a prototype based on the preliminary needs, start the conversation, and iterate the needs based on customer feedback. This way, the MVP can be found, but trying to do it upfront wastes a lot of energy. The MVP may only be known later in development when the function and performance features have been worked through.

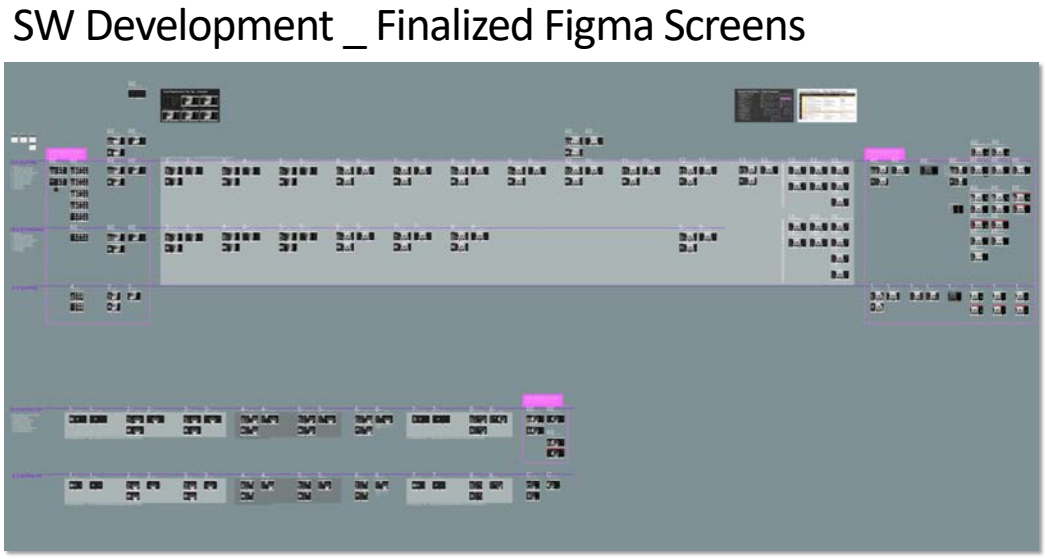
The industrial designer stated that by going through a process of concepting, prototype, evaluating, refining, evaluating, refining, etc., a point is reached, "*then you get to a point where there's nothing left to refine because you've solved all the issues"* (C1-I1). Conversely, as the needs evolved into design features and functions, it was stated that it is essential that the team reevaluate and check that they are still targeting the user needs and that the resulting design has come from an accurate interpretation. As the development process is followed, it becomes more and more technical. Therefore, the ability to trace the design to the overall unmet need is paramount.

Figure 6-6: Figma Screenshot Diagram 1



Source: UX workflow (C1-D4)

Figure 6-7: Figma Screenshot Diagram 2



Source: UX workflow (C1-D4)

6.4.3.6 Discovering Customer Insights

The customer insight example discussed during the interviews was known as the 'risk factor tab'. To meet the differing surgeon needs, the team played with multiple ways of

showing a simplified version of the data together with a more complex view. Thinking as engineers, they provided all the data necessary for the surgeon to make a fully informed decision on acetabular cup placement. However, in practice, the surgeons only used a subset of data. The subsequent insight was that they had made the solution overcomplicated; surgeons were using their training and experience of the cup orientation to make most decisions. The team had to step back and answer how they could make this simpler and complement what the surgeon was doing in practice,

> *"This is the learning, I guess, the insight. They didn't really care about the specific number because they knew they weren't going to be accurate, so they didn't really care whether it was 10 or 11. They really cared about, crudely putting it into a bucket. Are you likely to have an impingement problem, or you are not going to have an impingement problem? And they just boil down to that straightforward kind of need, you know? A normal patient is at risk, or a normal patient is not at risk. The next category is a normal and abnormal patient, which is not at risk, or normal is OK, but abnormal is at risk"* (C1-I3).

Though the software was capable of high accuracy, it was discovered that the surgeon's expectation of accuracy was low. Once this was realised, the team still needed to meet the needs regarding what the surgeons said about the data shown to the doers and real-thinkers. They did not want to be overwhelmed by information but wanted to, *"Be able to lift the hood and see the engine"* (C1-I3).

This led to the following insight: they wanted to feel like experts. A design analogy the R&D Lead Engineer used was the classic video recorder remote control, "*a little hatch you can open and all these extra buttons that no one ever uses"* (C1-C3). To address the insight, the team moved most data to a second screen accessible from the initial simplified screen. The second screen was referred to as the 'risk factor tab'. Through further design iterations, the data showing on the risk factor tab was reduced and eliminated to the point that the risk factor tab was eventually made redundant. The remaining data could be included on the initial screen without over-complicating the user interface. The software engineer concluded they might have got the solution quicker if the innovation team had started with a basic concept with minimal information and built up from the base instead of including all the data that could be possibly asked for (feature full) and then going

through the process of elimination to get to what the user was wanting. The MVP may have been different, with either using the top-down or bottom-up direction to find the ideal solution. The R&D lead engineer stated,

> *"It felt like a long journey, you know, identifying all of these features that we wanted in the advanced type and then slowly realising that many weren't useful and didn't really work and were confusing and causing more problems than they solved and then eventually coming right back to this basic kind of solution… it was an awful lot of effort to come up with what looks like quite a simple solution. And people might think, why didn't you just start there? But we had to walk that path, I think, to get where we've got"* (C1-I3).

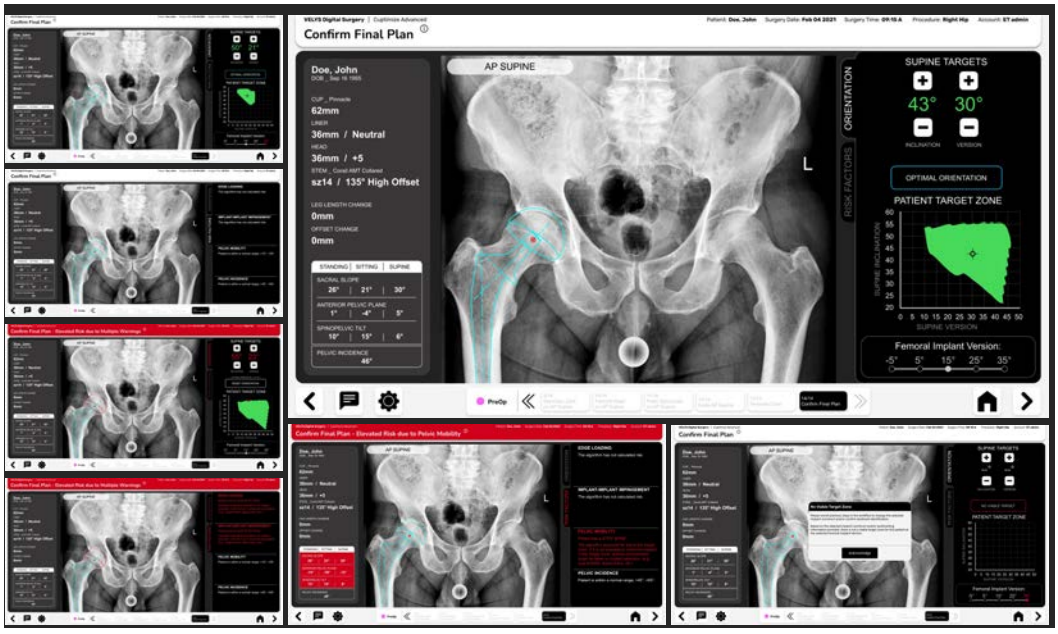
Team members also saw additional improvement opportunities when creating the prototype's successive iterations. If they found areas to make the process flow more straightforward and these did not take a significant resource, they did it, justifying that they were now becoming the experts. They were starting to make several customer-related decisions themselves. So, extra features and data were added. However, after internal discussion, some were removed to retain the crucial insight of simplicity and not feature-rich functionality. The Software Engineer explained the aha moment:

> *"When initially creating the output, we have a graph of inclination inversion. It's like our target zone where the acetabular cup should be placed in this target zone of inclination inversion. And so, we wanted to have different reference frames output. So, suppose the surgeon is operating in a standing reference frame versus a supine reference frame. In that case, we want the surgeon to be able to know what the patient's risk level in each of those available positions is. We thought that this would be really useful for the surgeon to understand when the patient is seated, they're at higher risk of dislocation posteriorly. Therefore, I need to change the inversion a little bit more to try and prevent that, or vice versa. If they're in a supine position, they might be at risk entirely. We thought this was really important, and we were trying to make it clear and obvious. We had a bunch of conversations with a surgeon, and they said that this is confusing and it's not value-adding to them. And so, we actually had to rework our entire output because they didn't think that this output was valuable. We thought, as*

engineers, it would be super important, super valuable. But in the end, they didn't care. I guess. They really couldn't fully understand the different reference frames, how things were calculated, and what they meant. So, we ended up stripping all of the reference frames out of it, and we only have one singular reference frame, the reference frame either standing or supine, based on their pre-op X-rays" (C1-I4).

Consequently, a dashboard-style layout was adopted instead of the risk factor tab to meet the customer insight. The R&D Lead Engineer reported that though the dashboard is not an innovative idea, it does provide an existing mental model for the users to understand the data in a simplified manner. Therefore, it is an innovative solution for this type of surgical application.

Figure 6-8: Screenshots of the Spark Hip Planning Software



Source: UX workflow (C1-D4)

6.5 CONCLUSIONS

In combination with the evolving needs, participants mentioned that they had to go through a learning process, making sense of the information to discover insights. But they were always conscious that they were operating within the headline unmet need, setting the context in which they intentionally explored. They purposely started conducting observational work and, in parallel, conceptualised designs and tested the prototypes with

users. Together with the unmet need, the team began with an initial set of user needs that broke the unmet need down to the next level. Through an iterative process, the needs were refined, and customer insights were discovered. The discovery of the insights that were discussed, in particular the risk factor tab, was driven by the development of the design concept. The discovery process involved exploring a new and refined design concept and then reviewing the concept with the users to gain feedback and a deeper understanding.

Chapter 6 presented the findings of the within-case analysis of Case Study 1 Spark., which has led to the following six conclusions:

1. The participants recognise the difference between customer needs and customer insights and that new needs develop from discovering new insights. Additionally, a single insight may develop into a single or multiple needs.
2. The company uses the term ‘unmet need’ to describe the overall clinical need for the project. This is the context within which the innovation team explores.
3. The project team used rapid software prototyping, testing and interaction with a surgeon design team to gather and explore customer needs.
4. Customer needs evolve through an iterative process within the FEI, becoming more detailed and specific as new knowledge and understanding are gained.
5. Insights are discovered at increasingly lower levels as the front end progresses, which drives newer needs.
6. There was a suggestion that the MVP is a retrospective idea and cannot work on new radical innovations as the functions and features still need to be discovered in the early development stages. So, it is not possible to establish the minimum levels or functions.

6.6 SUMMARY OF PILOT CASE STUDY CHAPTER

The chapter presented an analysis of the Spark in response to RQ 1 and RQ 2. It has stated the following:

RQ 1) How are customer needs related to customer insights in practice in the work of innovation teams at the front end of innovation?

Customer needs and customer insights are understood. Customer needs develop from customer insights, whereby customer insights are discovered during the research of the unmet need during the front end process.

RQ 2) How does the process of discovering customer insights unfold within innovation teams?

The company has an established front end process, Cadence. However, the practices the innovation team use need to be formally established. First, the innovation team investigates the unmet needs to generate an initial set of customer needs, which is then used to develop a prototype for testing with the surgeon design team. This process deepens the team's knowledge through an iterative process to understand the customers, which produces new insights that develop into unique needs that drive the prototype design. This front end iteration process is repeated until the innovation team is satisfied with a viable solution.

The pilot study will be used to inform the data collection and findings for RQ 1 in Chapter 7, for RQ 2 for the retrospective case study (Chapter 8), and for longitudinal case studies (Chapter 9).

CHAPTER 7 FINDINGS FOR RESEARCH QUESTION 1

7.1 INTRODUCTION

Chapter 7 addresses RQ 1: *How are customer needs related to customer insights in practice in the work of innovation teams at the front end?* The pilot study (Chapter 6) will be used to inform the data collection and findings for RQ 1. The question has been answered based solely on the findings of the interviews and looked to identify the views of practitioners. The findings have been broken down into three sections: 1) understanding customer needs, 2) understanding customer insights, and 3) the relationship of customer needs to customer insights. This structure was chosen as it follows the same structure as the interview. Firstly, the participant was asked to define in their own words a need and an insight and their relationship with each other. Secondly, the participant was shown PowerPoint slides (refer to Appendix B.6) that had the definitions for a need and insight that were created from the SLR. This order was chosen to avoid biasing the participant with the pre-established definitions so that an unprompted response could be captured first. The SLR definition for a customer need is a statement crafted by the innovation team that interprets the market research data and defines the customer's future benefit from and value of a product's use (refer to Section 2.5.2). The SLR definition for customer insight is an expression of deep knowledge about customers that leads to an actionable, non-obvious, creative solution (refer to Section 2.6.1).

The chapter will first discuss the perspectives from each of the case studies to understand customer needs and insight into their relationship; then, it will synthesise the findings. The chapter includes the following sections:

- Data collection
- Data analysis
- Findings
    - Understanding customer needs
    - Understanding customer insights
    - Relationship of customer needs to customer insights

- Conclusions
- Summary of findings chapter

7.1 DATA COLLECTION

Data was collected from 20 interviewees of the retrospective case studies. At the beginning of the interview, prior to the questions for RQ 2, the participants were asked about their understanding of customer needs, customer insights and the relationship between these two concepts. Table 7-1 shows the list of interviewees; a complete description and details of each interview can be found in Appendix L.3.

There were two options available for the analysis for RQ 1. Firstly, the analysis could have been conducted on all 20 participants interviewed collectively, removing the case study approach, or, secondly, the analysis could have kept the interviews within their case study. The analysis approach was to maintain the interview data within the cases to see if there were any differences or similarities between the understanding of needs and insight across the cases. The findings of this approach will be discussed in Section 7.5.

Table 7-1: RQ 1 Interview Participant List

Case Number	Case Name	Case Participant	Role	Interview Date
1	Spark	C1-I1	Industrial Designer	05 January 2022
Discussed in Chapter 6		C1-I2	Marketing Director	06 January 2022
		C1-I3	Lead Engineer	07 January 2022
		C1-I4	Engineer	07 January 2022
2	Archway	C2-I1	Principal Design Engineer	25 January 2022
		C2-I2	Project Director	27 January 2022
		C2-I3	Marketing Director	31 January 2022
		C2-I4	Industrial Designer	31 January 2022
3	Barricade	C3-I1	Engineer	18 January 2022
		C3-I2	Marketing Director	25 January 2022
		C3-I3	Lead Engineer	01 February 2022
		C3-I4	Human Factors Engineer	19 April 2022
4	Amlagam	C4-I1	Engineer	14 January 2022
		C4-I3	Industrial Designer	19 January 2022
		C4-I2	Industrial Designer	14 January 2022

		C4-I4	Marketing Director	19 April 2022
5	Minerva	C5-I1	Lead Engineer	07 February 2022
		C5-I2	Industrial Designer	18 February 2022
		C5-I3	Project Manager	22 February 2022
		C5-I4	Marketing Director	09 March 2022

Source: Author

7.2 DATA ANALYSIS

The responses from the 20 participants were coded into 1) understanding customer needs, 2) understanding customer insights, and 3) relationship of needs and insight. Table 7-2 shows the data structure for the codes and the number of responses for each code.

Explain the analysis process for RQ 1.

Table 7-2: RQ 1 Data Coding Structure

Case Number and Name	**Code**	**Number of Codes**
Case 1	Defining a customer insight	22
Spark	Defining a customer need	26
	Relationship of a need to an insight	12
Case 2	Defining a customer insight	31
Archway	Defining a customer need	43
	Relationship of a need to an insight	19
Case 3	Defining a customer insight	63
Barricade	Defining a customer need	36
	Relationship of a need to an insight	16
Case 4	Defining a customer insight	22
Amalgam	Defining a customer need	28
	Relationship of a need to an insight	15
Case 5	Defining a customer insight	32
Minerva	Defining a customer need	32
	Relationship of a need to an insight	12

Source: Author

7.3 FINDINGS

The following sections present the findings and are broken down into three sections: 1) understanding customer needs, 2) understanding customer insights, and 3) Relationship of Customer Needs to Customer Insights. The findings are reported per case, as it is critical to see if there are similarities or differences between the cases. This chapter reports on cases 2, 3, 4, and 5; case 1 Spark was reported on in Chapter 6. Following this section, a cross-case comparison is reported (Section 7.5).

7.3.1 Understanding Customer Needs

7.3.1.1 Archway Case Study 2

The participants in Archway confirmed they understood what a customer need was. In uncovering needs, it was stated that needs come from a market disturbance and that they are *"an unmet something in the marketplace"* (C2-I2). Furthermore, needs are seen as *"a pain point or area of opportunity for an existing product or service"* and are *"some other functional belief or idea that's long held by them that sort of drives their actions"* (C2-I3). It was also reported that with mature products, the new needs are sometimes complex to find, and customers state that they are happy with their existing products.

It was recognised that customers sometimes need to learn what their needs are. The Project Director (C2-I2) stated, "A lot of times, *customers may not even know they need it. That's an interesting spin on it. So, here's the problem: If you go out and ask potential customers what your needs are, They say I'm satisfied with what I have".* He also confirmed that it was understood that a need can evolve, and a need identified at a point in time can become obsolete if the market changes, *"The market shifted, and it did make sense".*

In summary, the participants could describe a customer need in their own words. Refer to Appendix D.2 for the customer need definition quotes from each of the participants. The participants all agreed that the expanded explanations from the SLR were helpful. The definitions in the SLR provided a nuanced understanding of customer needs that could then be articulated to the interviewees. They understood that customers sometimes do not recognise they have needs, but needs can come from market

disturbances and pain points. Furthermore, the participants support that a need should reflect the future but only partially support that the team crafts a need. There was limited support for the idea that a need is also a statement of value and benefit. Refer to Appendix D.3 for evidence of supporting quotes.

7.3.1.2 Barricade Case Study 3

Describing their thoughts on customer needs, the four participants agreed with the proposed definition. The Marketing Director confirmed he interprets what the customer says and what they observe into a need statement. For instance, he tries to *"Understand our customers' challenges, and they're looking to solve problems"* and *"translate what a customer says and things that we can act on, whether it's actually a statement and it's an idea or concept"* (C3-I2). The participants emphasised that observing the customer doing the job was crucial to understanding the customer's needs, as the needs are rarely a direct statement by the customer. Though it was admitted that customers (typically surgeons as the users) try to "dictate problems, issues or dictate what they think solutions are" (C3-I3), afterwards, the team takes this input and shapes the needs. The Marketing Director (C3-I2) discussed the future part of the need definition; he suggested a need weakens over time, for example, *"I think that is a very fair statement around customers' future. We are trying to project the future. And I think innovation, the challenge that is delivering the innovation in the future that we have foreseen and the longer we delay, the less relevant our understanding the need becomes"*. The Human Factors Engineer (C3-I3) considered usability as core to a need, *"Like those could be related to safety, which is in human factors like what we're really concerned about is, can it be used safely and effectively?"* However, he admitted that with a more radical product, it is challenging to observe a customer using a product that does not have an equivalent existing product.

In summary, the participants in the case study positively described a customer need in their own words. Refer to Appendix E.2 for the customer need definition quotes from each of the participants. Furthermore, the participants confirmed they fully supported the definition of customer need, refer to Appendix E.3 for evidence of supporting quotes.

7.3.1.3 Amalgam Case Study 4

A theme came across from the participants that customer needs are formed from customers' frustration that they cannot do precisely what they want to do. It was mentioned that these are found when someone articulates a pain point; it is then followed up with observations to confirm the pain point. The Industrial Designer had the view that needs are articulated by the customer, then interpreted into engineering requirements which can then be validated for usability; *"It's that translation of what are they actually asking for. A customer need would be a written requirement that the system has to fulfil. But in general, it's something that can be verified, validated through an engineering process"* (C4-I2). The Industrial Designer further explained his thoughts on the difference between wants and needs:

> *"I think the need and one interesting bit, you'll get people that say, 'I need this', and you're like 'how do you want it?' is it actually going to change what you're doing or is it how you perceive you're going to do it. And I think trying to distinguish between those two is quite interesting. And because you'll get a lot of searches and you want something, so we develop it for them, whereas there might be a market need for something that is not that, but it does still solve that problem. I think there are two buckets with it in terms of needs and wants"* (C4-I2).

This view was also backed up by the other Industrial Designer:

"*I've sat on a few projects where it's like, we know what the surgeon wants, but feel like we're never going to use those instruments, we're never going to go forward with that. So, we have to remove that bias and make sure that that need is a general need that they actually want and need, because otherwise, you're in that grey space of delivering something that no one actually is going to utilise because we think we've understood it, but we've kind of moulded it into something else"* (C4-I3).

Validation and uncovering of the actual needs came across in the interviews. Validation of needs was described as ensuring the need was addressing the fundamental problem and not the superficial issue that is caused by the problem; this was analogous to root cause analysis and the 5-whys tools. The Marketing Director had the perspective of the various customers in the value chain: *"I try to categorise them in two different*

buckets. I think about the end customer, so the patient will ultimately receive the product as well as the surgeon who is implanting the products. Customer needs that would be defining, 'What is it that customer aspires to have available to them to meet the needs of their customers?'" (C4-I4).

In summary, the participants described a customer need in their own words. Refer to Appendix F.2 for the customer need definition quotes from each of the participants. They understood that there are issues with articulated wants versus needs and that the need is a statement that the team created from listening to and observing customers. Furthermore, the participants confirmed they supported the three parts of the definition of customer need. Refer to Appendix F.3 for evidence of supporting quotes.

7.3.1.4 Minerva Case Study 5

Generally, the participants in the Minerva case study agreed with the definition of customer needs. The Lead Engineer and Project Manager focused on their understanding of the unmet clinical need versus the customer need. The Lead Engineer explained:

> *"When we think about the customer need, we're thinking about an unmet clinical need to improve an outcome. A strategic product direction and an unmet need. I want to distinguish that I think there are unmet needs which are the drivers of our identification of new technology and innovation. But then there's also customer needs, which might be, if we're building a laparoscope, we need to have it be autoclavable, and we need it to have a certain size and form factor. Now, those are not unmet needs; they're differentiated from sort of the strategic unmet need. And then we do an internal analysis to then try to extract what we believe. We call them customer input requirements (CIR), customer needs the product to do X, Y or Z"* (C5-I1)

The Lead Engineer also confirmed that the interpretation of what the customer says to the customer need was crucial. When the team are talking to many customers (surgeons), they balance the inputs to ensure that they find the actual need; "*Not every surgeon agrees, nine out of ten surgeons may agree that this is a need, but one out of ten does not. So, does that mean it's not a legitimate need because one surgeon does not agree? So, we still have to say what we believe this is in general"* (C5-I1). The Industrial Designer

considered the customer's needs with reference to the contextual environment, not just the needs that are associated with the physical product:

> *"Products are useful, if by just using this product or is it the experience that encompasses that product. So, I think there is a little bit more depth that could evolve in this kind of statement, but it's broader about the customer experience and the journey and that what we're trying to craft. Yes, there are clinical things that our products do better, faster-performing products or helping to heal. But I think we're going to start to evolve our product portfolio into more customer journey-based experiential things, and our products will be part of that. I think the experience that holistically could be a better way to kind of maybe end that statement to kind of keep it together"* (C5-I2).

In summary, the participants confidently described a customer need in their own words. Refer to Appendix G.2 for the customer need definition quotes from each of the participants. Furthermore, the participants support that a need should reflect the future but only partially support that the team crafts a need. There was limited support for the idea that a need is also a statement of value and benefit. Refer to Appendix G.3 for evidence of supporting quotes. A summary of the participants' responses to the customer need definition can be seen in Table 7-3, which will be discussed in detail in the cross-case comparison, Section 7.5.

7.3.2 Understanding Customer Insights

7.3.2.1 Archway Case Study 2

When describing customer insights, the participants used 'understand' as a crucial aspect in discovering insights. Statement examples of this are:

> *"It is a place where I really understand what it is to do, what he or she is challenged to do"* (C2-I1).

> *"A lot of times we look at insights at this face value, but I think there's art in the science to really understand like what's driving a user's behaviour"* (C2-I3).

Additionally, the responses supported the view that customer insight is more profound than a need, *"I've gone above and beyond, and I've delved into their world, and by doing so, I can perhaps deliver something that they are going to be delighted in"* (C2-I1). This statement refers to the Kano model, which uses the word 'delighted'. The Project Director (C2-I2) had a perspective in describing an insight, *"It is my viewpoint of their viewpoint. The viewpoint of how it meets their needs or doesn't meet their needs";* thus, his interpretation of their world. He further stated that insights are typically seen as positive. Still, he suggested that they can be negative too, *Iit could be negative feedback. It doesn't have to be positive. We get a lot of customer insights that tell us we're doing the wrong thing"* (C2-I2). An aspect of the customer insight definition that was questioned was the 'solution' term; they disagreed that an insight should reference a solution. The solution suggests that an insight is further down the development cycle.

In summary, the participants in the case study were able to explain in their own words what a customer insight is, using terms such as, '*It's our interpretation of a customer's desires or observations of a problem"* (C2-I1), refer to Appendix D.2 for the customer insight definition quotes from each participant. Regarding the definition, the participants supported the idea that an insight is an expression of profound knowledge, actionable and non-obvious. They did not support that it represented a solution; for instance, one participant stated that it may be possible to solve but should not be a solution. Refer to Appendix D.4 for the participant's responses to the definition in the literature.

7.3.2.2 Barricade Case Study 3

The participants agreed that a customer insight is an interpretation by the team, a deeper understanding of the customer's problem, *"You dig in deeper and discover what the actual source of the problem is"* (C3-I3). The Marketing Director expanded, stating that insights are not just laying out on the ground, "*It's our interpretation of a customer's desires or observations of a problem, so customers said something that's really insightful. Often, it's born out of the customer's direct knowledge of their practice or market but ultimately still is our interpretation of what they said and what they meant"* (C3-I2). The Lead Engineer also stated that, *"It's learning and insight—learning something that only they can share because they are the user or the person who's experienced it. Sharing experiences that essentially only they have that I cannot have, I can't have these*

experiences because they're the ones that are in whatever, in surgery or in pain or in whatever else" (C3-I3).

In summary, the responses demonstrated that they understood the meaning of a customer insight. They work diligently to decipher what the customer is telling them and combine this with observation to discover the deeper meaning that led to the insight. The participants in the case study were able to explain in their own words what a customer insight is. Refer to Appendix E.2 for each participant's customer insight definition quotes. Regarding the definition, the participants supported that an insight is an expression of profound knowledge. They did not support that an insight was actionable, non-obvious or creative. They did not mention the solution aspect of the definition. Refer to Appendix E.4 for the participant's responses to the definition in the literature.

7.3.2.3 Amalgam Case Study 4

The participants in Amalgam did not see an insight as a separate concept but more as an extension of a customer need. Both the Engineer (C4-I1) and the Industrial Designer (C4-I2) defined it as feedback on what the customer is doing. For example, it, *"Feels similar to a customer need 'I need this to do this', they're not explicitly calling it a need. They're discussing or describing a workaround on how they're completing that procedure"* (C4-I1). However, after further discussion, he did explain that insight is the process of *"Digging into the depths of the user need and the customer need to provide it, provide something that meets and exceeds their user need"* (C4-I1). The Industrial Designer (C4-I2) spoke about how insights provide a better understanding of where customer feedback comes from. This level of understanding should include *"influencing factors",* for instance, the environment, context, the type of questions, and the way questions are asked, as this affects the information that is received and, ultimately, the customer insight. For example:

> *"I think that's more observed. So, if you're doing ethnographic research or something like that, and you see them do something in a certain way. There's a term for it, 'alert behaviour'; they're doing it in an unexpected way, and they've learned how to do it in their own way to overcome that challenge. That's kind of giving you those insights, things that aren't readily available"* (C4-I3).

The Marketing Director (C4-I4) described customer insights through the lens of success and *"Understanding what it is that a customer, in fact, desires to have, I would also say what their definition of success is"*. He also clarified it included facts, such as *"How many procedures do they do? Where did they train on their procedures? What is their style of learning when those types of even demographics would be part of a customer insights?"* (C4-I4).

In summary, the participants in the case study needed to be more precise on an insight; they defined it as feedback and information about the customer but also understood it was more profound knowledge. Refer to Appendix F.2 for the customer insight definition quotes from each participant. The participants supported that an insight is an expression of profound knowledge, actionable and non-obvious. They did not support that it represented a solution. Refer to Appendix F.4 for the participant's responses to the definition in the literature.

7.3.2.4 Minerva Case Study 5

In this case study, the Lead Engineer (C5-I1) mentioned that 'data points' were the crucial feature of customer insights. Their goal in product innovation is to collect many little data points for analysis. It was stated that not all these insights are fulfilled: *"I think the customer insights are a collection of data points that the teams go out into the field, whether they be through market research activities or whether they be through observations. But it's collecting a lot of data points, which are customer insights"* (C5-I1). The Marketing Director described customer insights as:

> *"The nugget of information that allows you to do something different to support that need, that gives you a kind of a glimpse into why that need is important and how you might deliver. I think the insights are nuanced, and there's always something a little different about each speciality where someone practises or what their training experiences are. It's digging a level deeper to understand the need versus just knowing what it is; you talk about the need, and then it's through that conversation that you get to the insight" (C5-I4).*

The terms 'actionable', 'non-obvious' and 'solution' created a lot of discussion among the participants. The Lead Engineer (C5-I1) stated that as insights are data points,

they cannot be actionable, non-obvious or a solution; they are only observations. As such, he rejected this definition except for an expression of profound knowledge. The Industrial Designer liked actionable but preferred practical and implementable, *"Actionable, practical, and implementable for me, is that there isn't like the area to fail because you can have customer insights. There needs to be an area of exploration to figure out if this is the right thing to do" (C5-I2)*. He did have an issue with non-obvious solutions.

In summary, the participants in the case study were able to explain in their own words what a customer insight is. Refer to Appendix G.2 for each participant's customer insight definition quotes. Regarding the definition, the participants supported that an insight is an expression of deep knowledge. They did not support that an insight was actionable, non-obvious, creative or a solution. Refer to Appendix G.4 for the participant's response to the definition in the literature.

7.3.3 Relationship of Customer Needs to Customer Insights

7.3.3.1 Archway Case Study 2

Discussing the relationship between needs and insights, the participants in the Archway case all agreed that they are 1) separate concepts, 2) have a relationship with each other, and 3) overlap.

"There's probably overlap between the two of them, but I don't think that they are the same. We use the word need in my mind, and it is something that has to be delivered. Whereas an insight is something I can act on" (C2-I1)

It was explained that that insights lead to a need, "*I don't know if you can generate customer needs without generating customer insight. A lot of times, we use customer insights to lead to a customer's need"* (C2-I2). Additionally, the Industrial Designer suggested that insights evolve into needs. However, the Marketing Director described the relationship as more reciprocal, the two concepts complementing each other: *"Insight explains or provides the explanation and understanding of the need in a more actionable and sort of detailed way unique to a customer"* (C2-I3).

A summary of the participant's responses on the relationship between needs and insights showed that they agreed they are separate concepts but are overlapping. Refer to

Appendix D.2 for each participant's response to the relationship. There was agreement on the sequence that needs follow insights. From these findings, it can be stated that needs and insights influence each other, and insights drive a deeper understanding of the customer's problems. Appendix D.5 summarises the relationship feedback from the participants, with representative quotes.

7.3.3.2 Barricade Case Study 3

Discussing the relationship between needs and insights, the participants described that needs come from the customer and that insights are the learnings and input from the customer. The Marketing Director (C3-I2) mentioned that many needs could be easily found, but for insights, they may only discover two or three insights. When deep insights are discovered, they drive the real customer need, which he understood as the difference between needs and insight.

> *"If you don't do that deep insight, you don't provide the actual solution, you might provide a solution that seems to fulfil the customer needs superficially, but long term it may not provide the long-term benefit that you want because it didn't solve the base problem" (C3-I3).*

The team are looking to find numerous needs that are easy to find, and they are only expecting to find a few insights. However, these insights will drive the fundamental needs that provide higher benefits to the customer.

A summary of the participant's feedback on the relationship between needs and insights showed that they agree they are separate concepts but are connected. Refer to Appendix E.2 for each participant's response to the relationship. Additionally, two participants confirmed the sequence that needs follow insights. From these findings, it can be stated that needs and insights influence each other and drive a deeper understanding of the customer's problems. Appendix E.5 summarises the relationship feedback from the participants, each with representative quotes.

7.3.3.3 Amalgam Case Study 4

Both the Industrial Designers agreed that needs are the basic requirements and insights bring creativity and innovation and, therefore, complement each other. As such, they overlap in the process.

> *"Customer insights seem more like something that you would do to help you meet those customer needs. The need defines the product and its delivery and the verification, whereas the customer insight is creative" (C4-I2)*

> *"The needs are probably like the building blocks of your projects. And then I think insights are potential enhancements" (C4-I3)*

They also spoke about how needs are easier to find in market research and that insights are unique and push the boundaries. The Marketing Director (C4-I4) suggested that needs were a subset of customer insights, and insights are the broader understanding of the customer.

In summary, the participant's feedback on the relationship between needs and insights showed two thoughts: that insights are a subset of needs and two thoughts that either overlap or are separate. Refer to Appendix F.2 for each participant's response to the relationship. Additionally, one participant confirmed the sequence that needs follow insights, and two participants stated that insights follow needs. Appendix F.5 summarises the relationship feedback from the participants, each with representative quotes.

7.3.3.4 Minerva Case Study 5

Discussing the relationship between needs and insights, the Lead Engineer (C5-I1) described the process by which insights are analysed into needs. Insights come first and are discovered through market research.

> *"Customer insights are the beginning of the process where you did the observation or whatever type of market research you undertake, and they've got lots of these data points, these statements and things and observations by the team, and they are then condensed into certain levels of needs" (C5-I1).*

The Project Manager (C5-I3) described a similar process, where the non-technical insights are translated into needs. In contrast, the Marketing Director saw needs as constant across customers, but insights change, *"those insights may be different across*

different stakeholders, but the needs generally remain the same" (C5-I4). He also described the relationship as circular, as insight drives needs, and needs can also drive insights.

A summary of the participant's feedback on the relationship between needs and insights showed that three participants confirmed the sequence that needs to follow insights. Refer to Appendix G.2 for each participant's response to the relationship. Appendix G.5 summarises the relationship feedback from the participants, each with representative quotes.

7.4 CROSS-CASE COMPARISON

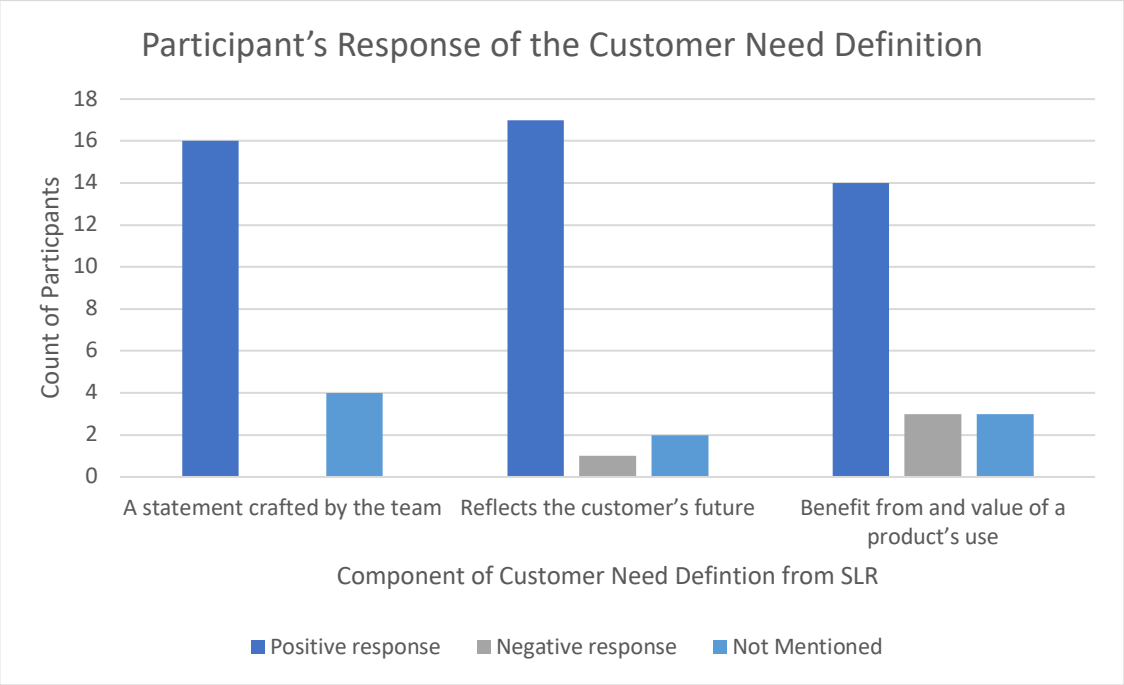
In reviewing the proposed definition of a customer need, the data has demonstrated that the 20 participants were generally supportive of the definition. Furthermore, all participants could describe a customer need in their own words. Table 7-3 shows that of the three components of the definition, about 75% of the participants were positive.

- A statement crafted by the team with 16 positives.
- Reflects the customer's future with 17 positives.
- Benefit from and value of a product's use with 14 positives.

For the cross-case comparison for understanding customer needs, the participants in the case studies were able to describe a customer need in their own words. Case studies 3 and 4 confirmed they supported the three parts of the definition of customer need. However, case studies 1, 2, and 5 needed more support for the idea that a need is also a statement of value and benefit. The participants all agreed that the expanded definition was helpful in explaining the definition and providing a deeper context. The findings showed that the components' a statement crafted by the team' and 'reflects the customer's future' are broadly supported and that 'benefit from and value of a product's use' is only partially supported. The participants were able to describe a customer need in their own words, but when presented with the customer needs definition that was established in the SLR, there was no unanimous agreement. Still, they did agree on the expanded definition, as shown in Figure 7-1. Therefore, it can be concluded that innovation teams may require a better understanding of the specific components of a customer need to ensure that they

capture a need clearly and concisely. Table 7-3 provides an overview of the responses of each participant

Figure 7-1: Summary Participant's Response to the Customer Need Definition



Source: Author

Table 7-3: Summary of RQ 1 Participants' Response to the Customer Need Definition

Component of Customer Need Definition from SLR	**A statement crafted by the team**	**Reflects the customer's future**	**Benefit from and value of a product's use**
Case Participant	**Positive/Negative feedback**	**Positive/Negative feedback**	**Positive/Negative feedback**
C1-I1	+	+	+
C1-I2	+	-	-
C1-I3	+	+	+
C1-I4	+	+	+
C2-I1	NM	+	NM
C2-I2	+	+	+
C2-I3	NM	+	-
C2-I4	+	NM	+
C2-I1	+	+	+
C2-I2	+	+	+

C2-I3	+	+	+
C2-I4	+	+	+
C4-I1	+	+	NM
C4-I2	+	+	+
C4-I3	+	+	+
C4-I4	+	+	+
C5-I1	+	+	+
C5-I2	+	+	-
C5-I3	NM	NM	NM
C5-I4	NM	+	+
+	**16**	**17**	**14**
-	**0**	**1**	**3**
NM	**4**	**2**	**3**

'+'. This is a positive response (agreement) from the participants to the definition component

'-'. This is a negative response (disagreement) from the participants to the definition component

'NM'. Not Mentioned; means that the participant did not specifically discuss this aspect during the interview

Source: Author

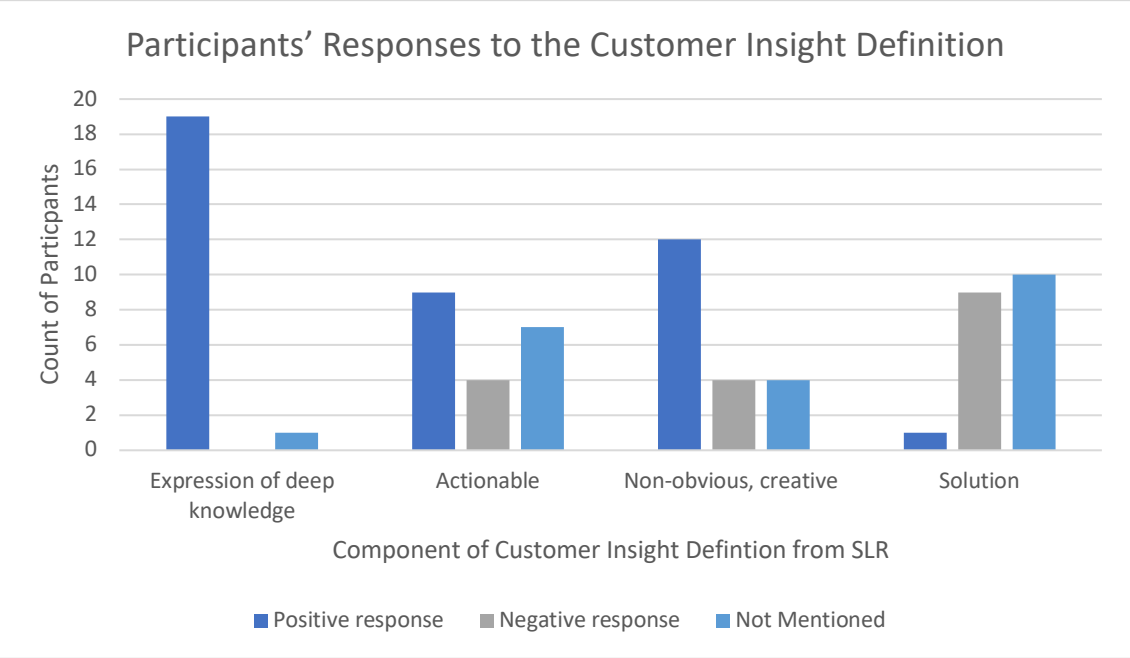
Reviewing the proposed definition of customer insight, the data has demonstrated that the 20 participants did not entirely agree with the definition. Figure 7-2 shows that of the four components of the definition:

- Expression of deep knowledge was supported by the participants, with 19 positive responses.
- Actionable only received nine positive responses.
- Non-obvious creative received 12 positive responses and four negative responses, so it can be suggested that this has partial support.
- The solution received ten negative responses and only one positive response; therefore, this needs to be supported.

For the cross-case comparison for understanding customer insights, the participants in the case studies could describe a customer insight in their own words. Refer to Table 7-4 for an overview of the responses for each of the three components parts of the

definition. Therefore, the cases provided similar responses, and there were no apparent differences between the cases.

Figure 7-2: Summary of Participants' Responses to the Customer Insight Definition



Source: Author

Table 7-4: Summary of RQ 1 Participants' Responses to the Customer Insight Definition

Customer Insight Definition from SLR	**Expression of deep knowledge**	**Actionable**	**Non-obvious, creative**	**Solution**
Case Participant	**Positive/Negative feedback**	**Positive/Negative feedback**	**Positive/Negative feedback**	**Positive/Negative feedback**
C1-I1	+	-	-	-
C1-I2	+	NM	+	-
C1-I3	+	-	+	-
C1-I4	+	NM	+	NM
C2-I1	+	+	+	-
C2-I2	+	NM	+	-
C2-I3	+	+	+	-
C2-I4	+	+	+	-
C3-I1	+	NM	-	NM
C3-I2	+	-	+	NM

C3-I3	+	NM	NM	NM
C3-I4	+	+	+	NM
C4-I1	+	NM	+	+
C4-I2	+	+	+	NM
C4-I3	+	+	NM	NM
C4-I4	+	+	+	NM
C5-I1	+	-	-	-
C5-I2	+	+	-	-
C5-I3	NM	NM	NM	NM
C5-I4	+	+	NM	NM
+	19	9	12	1
-	0	4	4	9
NM	1	7	4	10

'+'. This is a positive response (agreement) from the participants to the definition component

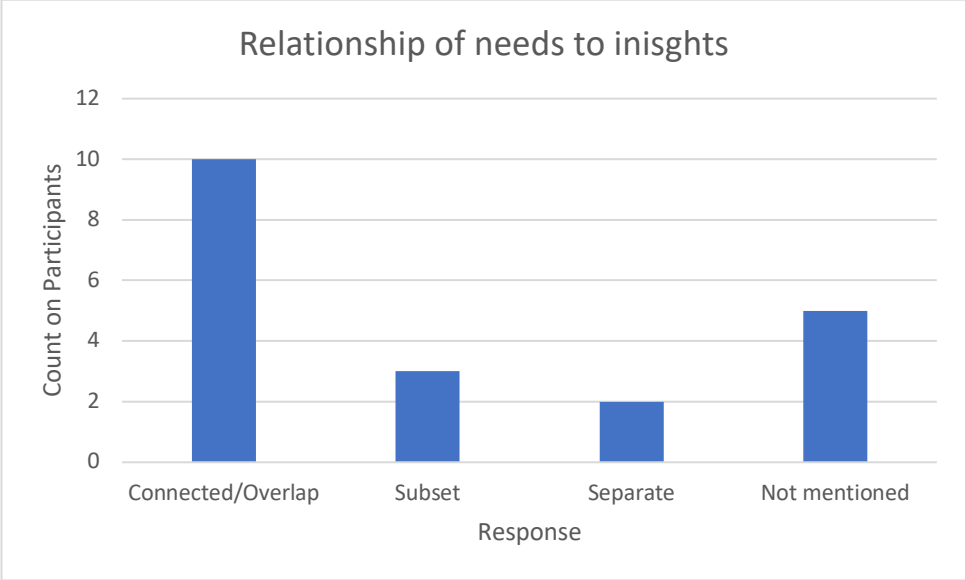
'-'. This is a negative response (disagreement) from the participants to the definition component

'NM'. Not Mentioned; means that the participant did not specifically discuss this aspect during the interview

Source: Author

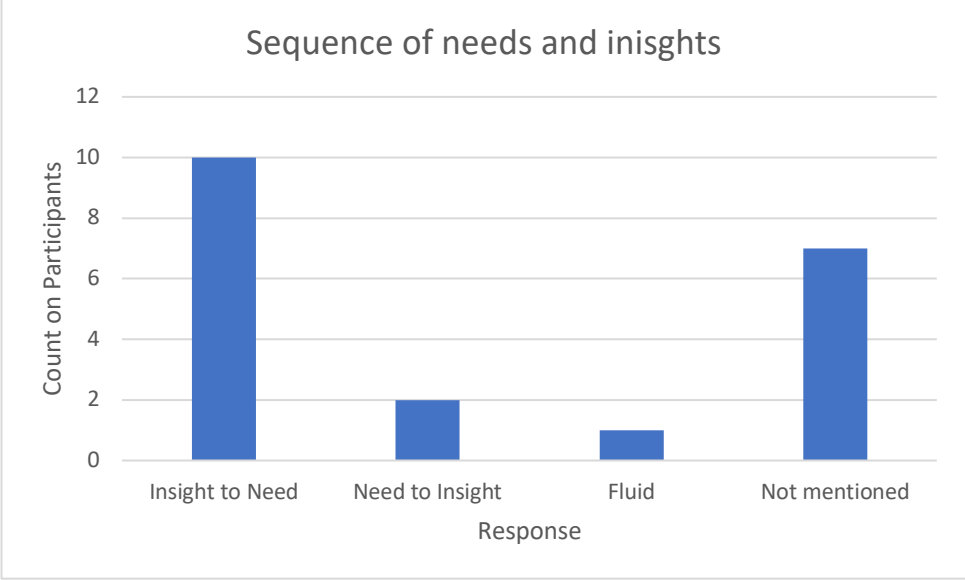
Evaluating the responses for the relationship between a need and an insight, the summary, Figure 7-3, shows that ten consider that the two concepts are connected or overlap. Three participants think that insights are a subset of needs. Looking at the sequence of needs and insight, ten considered that an insight leads to a need, with only two thinking the opposite, i.e., a need leads to an insight.

Figure 7-3: Summary of RQ 1 Participants' Responses to the Relationship



Source: Author

Figure 7-4: Summary of RQ 1 Participants' Responses to the Sequence

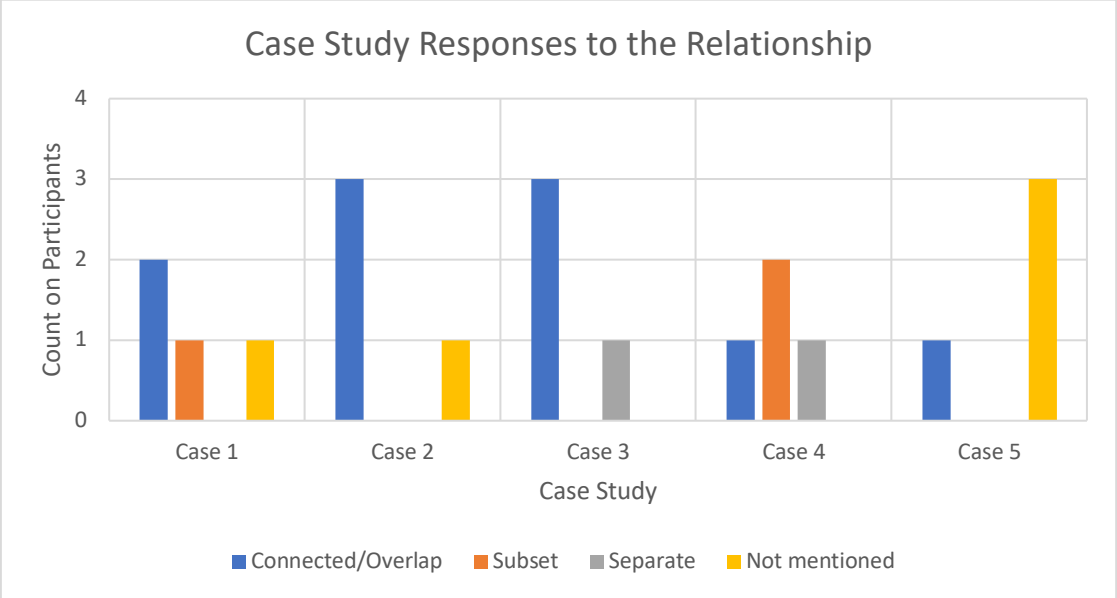


Source: Author

There was only agreement that the two concepts are overlapping and connected in cases 2 and 3. Cases 1 and 4 had a limited agreement among the participants. This is shown in Figure 7-5.

Therefore, the cases provided similar responses, there were no apparent differences between the cases.

Figure 7-5: Summary of RQ 1 Case Study Responses to the Relationship



Source: Author

Table 7-5: Summary of RQ 1 Participants' Responses to the Relationship

Case Participant	Relationship	Sequence
C1-I1	Connected	Insight to Need
C1-I2	Connected	Not mentioned
C1-I3	Subset	Fluid
C1-I4	Not mentioned	Not mentioned
C2-I1	Overlap	Not mentioned
C2-I2	Overlap	Insight to Need
C2-I3	Not mentioned	Insight to Need
C2-I4	Overlap	Insight to Need
C3-I1	Connected	Not mentioned
C3-I2	Separate	Not mentioned
C3-I3	Overlap	Insight to Need
C3-I4	Connected	Insight to Need
C4-I1	Subset	Not mentioned
C4-I2	Separate	Need to Insight
C4-I3	Overlap	Need to Insight
C4-I4	Subset	Insight to Need
C5-I1	Not mentioned	Insight to Need
C5-I2	Not mentioned	Not mentioned
C5-I3	Not mentioned	Insight to Need
C5-I4	Overlap	Insight to Need
Summary	**10 Connected/Overlap**	**10 Insight to Need**
	3 Subset	**2 Need to Insight**
	2 Separate	**1 Fluid**
	5 Not mentioned	**7 Not mentioned**

Source: Author

Table 7-6: Participants' Responses to the Customer Insight Definition by Function

Case Participant	Functional Area of Participant	Expression of deep knowledge	Actionable	Non-obvious, creative	Solution
C1-I2	Marketing	+	NM	+	-
C2-I3	Marketing	+	+	+	-
C3-I2	Marketing	+	-	+	NM
C4-I4	Marketing	+	+	+	NM
C5-I4	Marketing	+	+	NM	NM
C1-I3	R&D - Engineering	+	-	+	-
C1-I4	R&D - Engineering	+	NM	+	NM
C2-I1	R&D - Engineering	+	+	+	-
C2-I2	R&D - Engineering	+	NM	+	-
C3-I1	R&D - Engineering	+	NM	-	NM
C3-I3	R&D - Engineering	+	NM	NM	NM
C4-I1	R&D - Engineering	+	NM	+	+
C5-I1	R&D - Engineering	+	-	-	-
C5-I3	R&D - Engineering	NM	NM	NM	NM
C1-I1	R&D - Industrial Design	+	-	-	-
C2-I4	R&D - Industrial Design	+	+	+	-
C3-I4	R&D - Industrial Design	+	+	+	NM
C4-I2	R&D - Industrial Design	+	+	+	NM
C4-I3	R&D - Industrial Design	+	+	NM	NM
C5-I2	R&D - Industrial Design	+	+	-	-

Table 7-7: Participants' Response to the Relationship by Function

Case Participant	Functional Area of Participant	Relationship	Sequence
C1-I2	Marketing	Connected	Not mentioned
C2-I3	Marketing	Not mentioned	Insight to Need
C3-I2	Marketing	Separate	Not mentioned
C4-I4	Marketing	Subset	Insight to Need
C5-I4	Marketing	Overlap	Insight to Need
C1-I3	R&D - Engineering	Subset	Fluid
C1-I4	R&D - Engineering	Not mentioned	Not mentioned
C2-I1	R&D - Engineering	Overlap	Not mentioned
C2-I2	R&D - Engineering	Overlap	Insight to Need
C3-I1	R&D - Engineering	Connected	Not mentioned
C3-I3	R&D - Engineering	Overlap	Insight to Need
C4-I1	R&D - Engineering	Subset	Not mentioned
C5-I1	R&D - Engineering	Not mentioned	Insight to Need
C5-I3	R&D - Engineering	Not mentioned	Insight to Need
C1-I1	R&D - Industrial Design	Connected	Insight to Need
C2-I4	R&D - Industrial Design	Overlap	Insight to Need
C3-I4	R&D - Industrial Design	Connected	Insight to Need
C4-I2	R&D - Industrial Design	Separate	Need to Insight
C4-I3	R&D - Industrial Design	Overlap	Need to Insight
C5-I2	R&D - Industrial Design	Not mentioned	Not mentioned

In conclusion, the data has shown that the participants do have a good understanding of customer needs. However, they consider that customer insight is only an expression of deep knowledge about the customer. There was also disagreement regarding whether an insight was creative, non-obvious, actionable or a solution. Regarding the relationship, it can be proposed that needs and insights are considered separate concepts but have a degree of overlap. However, the degree of overlap was not explored in the research. Future research would be required to investigate the relationship further; the research could use a larger sample size (e.g., survey) from more companies and possibly more industries.

7.5 SUMMARY OF FINDINGS FOR RESEARCH QUESTION 1 CHAPTER

This chapter presented the findings that address RQ 1: *How are customer needs related to customer insights in practice in the work of innovation teams at the front end of innovation?* The question was answered based on the findings from five case studies and 20 interviews. The responses from the interviews were broken down into three sections: 1) understanding customer needs, 2) understanding customer insights, and 3) the relationship of customer needs to customer insights. It was shown that there is agreement on the definition of a customer need, but the definition of a customer insight needed to be fully supported. Apart from a customer insight being deep knowledge about a customer, any further clarification of the definition still needs to be determined.

CHAPTER 8 FINDINGS FOR THE RETROSPECTIVE CASE STUDIES

8.1 INTRODUCTION

Chapter 8 considers the findings for the retrospective cases for RQ 2: *How does the process of discovering customer insights unfold within innovation teams?* The chapter provides an overview of the other four retrospective case studies, which were called - Archway, Barricade, Amalgam and Minerva. The chapter includes the case study background information on each project, the data collected and a summary of the findings. The analysis was based on interviews and documents and will show the insight discovery process that the teams followed for each of their projects. Chapter 9 provides the findings of the longitudinal case studies, and Chapter 10 provides a cross-case analysis of the retrospective and longitudinal cases.

The research aimed to understand how customer needs are related to customer insights and the process for the discovery of customer insights. As such, the research was dependent on a customer insight emerging during the FEI process; therefore, combining retrospective case studies and longitudinal case studies approach has been used to mitigate the risk that the cases would not discover customer insights.

The retrospective case studies were selected as they are projects that were actively developing new products and working with customers and users, and to which the researcher had access (refer to the selection criteria in Section 4.4.3). The case studies were all also within a US multinational medical company, MedDevCo, that employs over 80,000 people worldwide with more than $50 billion in revenue and produces pharmaceuticals, medical devices, and consumer healthcare products.

The two terms ‘customer’ and ‘user’ have been used interchangeably in reporting on the case studies, as it is a difficult distinction to make in medical devices. Surgeons, nurses, operating room staff, and sales representatives are considered users of the devices in this context, along with patients for specific devices. But they also influence the purchasing and use of the device, so they can also be considered customers. Additionally,

this group of users are purposely engaged to gather customer needs, which is why, in RQ 1 findings, the teams typically use user needs instead of customer needs.

The participants were selected for the research because the innovation project was their primary job responsibility during this time. Appendix L.1 provides a complete list of retrospective case study participants. Other people also worked on the project on an ad-hoc basis but were not included in the data collection. Access to the interviewees was achieved by contacting the team members through the company email system. Then, if the interviewee agreed that they had the time and confirmed they had experience with the innovative project, a meeting was set up in their calendars. At the commencement of the interview, the researcher confirmed that confidentially and anonymity would be respected, and verbal agreement from the participant was recorded. The first part of the interview was spent explaining the research and the interview process. After this, the interviewee described their role and experience. The remaining time was used for the semi-structured interview using the guide shown in Appendix B.2. Microsoft Teams was used to record each interview. The interview recordings were transcribed using the auto-transcription service in the NVivo software.

For the description of the data analysis process, refer to Sections 4.6.1 and 4.6.1.1. The second-order coding for the four retrospective case studies in this chapter has been informed by the second-order coding from the first case study reported in Chapter 6. This was an iterative research approach, which involved 'simultaneous data collection and analysis, adopting comparative methods, and checking and elaborating' (Denzin and Lincoln, 2011, p. 360). As such, the second-order codes utilise similar titles to Chapter 6, which will aid in the cross-case analysis in Chapter 10.

Chapter 8 is organised as follows:

- Overview of the Project Archway case study 2
- Overview of the Project Barricade case study 3
- Overview of the Project Amalgam case study 4
- Overview of the Project Minerva case study 5
- Summary of retrospective case studies chapter

8.2 OVERVIEW OF THE ARCHWAY CASE STUDY 2

Project Archway is a product innovation within the surgical business unit. The business unit specialises in laparoscopic surgical devices. The marketing and R&D functions are in the USA. Archway is a new linear stapler for bowel surgery and uses new radical stapler technology. Surgical staples are used in laparoscopic surgery to connect bowel tissue after resection. The project consisted of a core team of four people who worked on FEI for the project over 24 months; these four were interviewed. The team consisted of marketing, engineering, and industrial design. The overall output of the project was aimed at developing a new product concept for a linear stapler. The main challenge of the project was to develop a new linear stapler that used the new staple technology and enhanced the user experience. By addressing these challenges, new insights were discovered.

8.2.1 Data Collection for Archway

Data collection was conducted in January 2022. The data sources consisted of interviews and company documents.

8.2.1.1 Interviews

The interviewees for the semi-structured interviews were drawn from both marketing and R&D. For details of each participant's role and responsibility, interview duration, and date, refer to Table 8-1. The total time of the interviews was 3 hours 19 minutes, an average of 50 minutes per interview.

Table 8-1: Details of Interviewees for Archway

Interview Number	Role, Job Title	Participant Case	Experience in NPD	Date	Interview Duration (min.sec)
1	Principal Design Engineer	C2-I1	19 years' total experience PhD	January 2022	50.16
2	Project Director	C2-I2	17 years in current business. 25 years' experience	January 2022	53.19

3	Marketing Director	C2-I3	3 years in current business. 15 years total	January 2022	44.54
4	Industrial Designer	C2-I4	2 years' total experience	January 2022	50.42
				Total	199 minutes

Source: Author

8.2.1.2 Documents

Five project documents were collected from the interviewees during the interview. These were documents that the interviewee referred to and authored; Table 8-2 lists the documents. The documents represented the key deliverables of the project, along with the prototype, the business case, unmet needs and project strategy, which were captured in the TPP, the design plan stated the project team organisation, user groups, main design challenges and the crucial design features and functions, the product requirements document listed the customer needs and engineering specifications. Finally, the NPD process and Cadence stage gate provided the formal requirements that the team followed.

Table 8-2: Document Details for Archway

Document Number	**Title**	**Document Content**	**Number of pages**	**Date**	**Author**
C2-D1	Target Product Profile (TPP)	TPP for the project	10	January 2021	Marketing Director
C2-D2	Design Plan	Outlines the project, the goals, the assumptions, current device, and the deliverables	5	May 2021	Principal Design Engineer
C2-D3	Product Requirements	Product Requirements including design inputs, outputs, and testing requirements	Excel file	June 2021	Principal Design Engineer
C2-D4	NPD process CP0258	Standard company procedure outlining the NPD process	40	Last revised June 2022	BU representative
Cx-D1	Cadence stage-gate guidance v11	Instruction on the Cadence stage-gate process and overview slide	25	October 2021	Business Unit

Source: Author

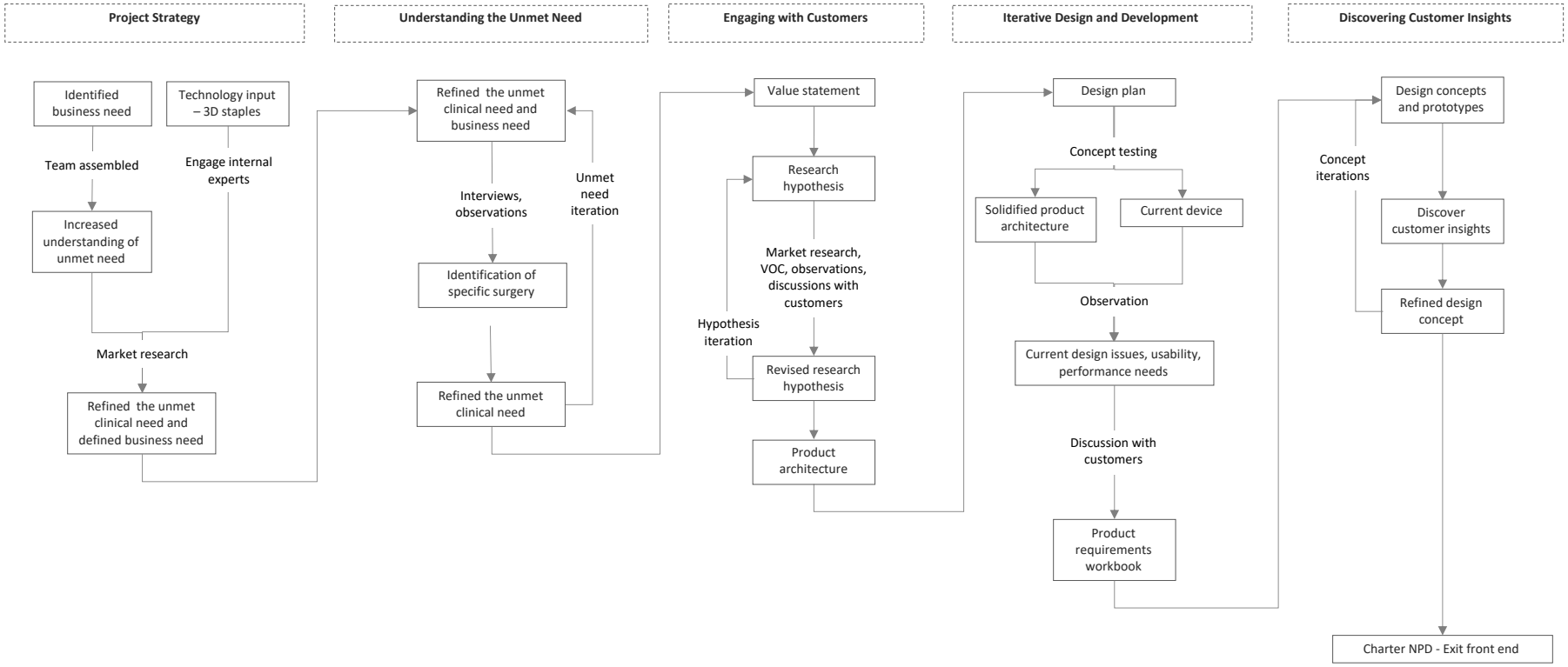
8.2.2 The Insight Discovery Process

8.2.2.1 Coding and Process Framework

The interviews covered the participant's experience through the FEI with this specific project; the interviews explored the crucial process steps, activities, and outputs in the process. The first-order coding generated 43 codes; these were then aggregated into five second-order codes. The aggregated second-order codes revealed that the team pursued five process steps through the FEI: project strategy, understanding the unmet need, engaging with customers, iterative design and development, and discovering customer insights. As a result, the team discovered two insights leading to the final product design. Furthermore, the coding of the interviews also revealed the inputs, actions, and outputs for each of the five process steps. To demonstrate the validity of the coding, Appendix D.7 provides the coding structure with representative quotes, and Appendix D.8 shows the data structure.

The inputs, actions, and outputs for each of the five process steps are shown in Appendix D.9 with the representative quote or reference to a document. Utilising the data found in the coding, an overview of the process was created; as such Figure 8-1 illustrates the team's process for the Archway case study. Finally, following the overview, a narrative describes the process with associated quotes to provide a richer understanding of the case study.

Figure 8-1: Framework for the Insight Process for Archway



Source: Author; based on Appendix D.9

8.3 OVERVIEW OF THE BARICADE CASE STUDY 3

Project Barricade is a product innovation within the orthopaedic trauma business unit. The business unit specialises in osteosynthesis trauma medical devices. The marketing and R&D functions are in Switzerland and the USA. Barricade is a new femoral plate that uses wireless technology to track bone healing after surgery.

The unmet need for the project is known in the orthopaedic trauma field - the ability to know if a fracture is healing (C3-D1). The current standard of care to know if a fracture is healing is an x-ray or a fluoroscopic image. However, this brings challenges, such as patient willingness to return to the hospital, post-operative timing, increased radiation exposure, the ability to read an x-ray to determine if healing is occurring, and the associated costs to the healthcare system.

8.3.1 Data Collection for Barricade

Data collection was conducted between January and April 2022. The data sources consisted of interviews and company documents.

8.3.1.1 Interviews

The four semi-structured interviews were drawn from marketing and R&D functions. The details of each participant's role and responsibility, interview duration, and date are shown in Table 8-3: Interview Details for Barricade. The total duration of the interviews was 3 hours and 10 minutes, with an average of 47 minutes per interview.

Table 8-3: Interview Details for Barricade

Interview Number	Role, Job Title	Case Participar	Experience in NPD	Date	Interview Duration (min.sec)
1	Engineer	C3-I1	7 years' total experience PhD	January 2022	49.11
2	Marketing Director	C3-I2	13 years in current business. 20 years' experience	January 2022	48.56

3	Lead Engineer	C3-I3	20 years' total experience.	February 2022	48.38
4	Human Factors Engineer	C3-I4	Less than 1 year PhD	April 2022	43.47
				Total	189.52

Source: Author

8.3.1.2 Documents

Four project documents were collected from the interviewees during the interview. Table 8-4 lists the documents.

Table 8-4: Document Details for Barricade

Document Number	**Title**	**Document Content**	**Number of Pages**	**Date**	**Author**
C3-D1	Target Product profile	TPP for the project	18	April 2022	Marketing Director
C3-D2	Product questionnaire	Questionnaire answered by surgeons on the plate design	36	November 2022	Marketing Director
C3-D3	Requirement Traceability Matrix (RTM)	Product requirement list	Excel file	February 2022	Lead Engineer
Cx-D1	Cadence stage-gate guidance v11	Instruction on the Cadence stage-gate process and overview slide	25	October 2021	Business Unit

Source: Author

8.3.2 The Insight Discovery Process

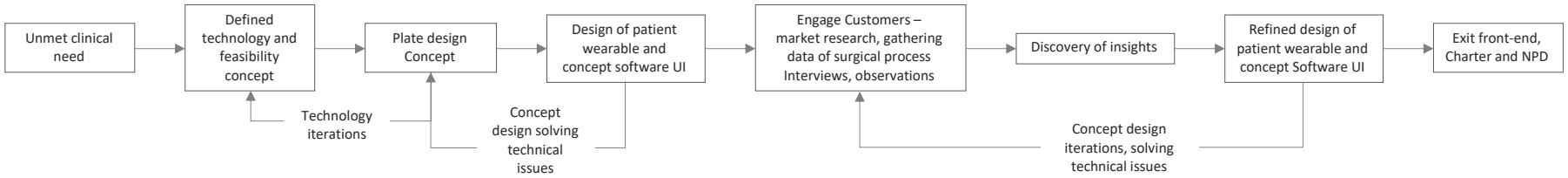
8.3.2.1 Coding and Process Framework

The interviews covered the participant's experience through the FEI with this specific project; the interviews explored the crucial process steps, activities, and outputs in the

process. The first-order coding generated 30 codes; these were then aggregated into four second-order codes. The aggregated second-order codes revealed that the team pursued four process steps through the FEI: understanding the unmet need, engaging with customers, discovering customer insights, and iterative design and development. Furthermore, the coding of the interviews also revealed the inputs, actions, and outputs for each of the process steps. To demonstrate the validity of the coding, Appendix E.7 provides the coding structure with representative quotes, and Appendix E.8 shows the data structure.

The inputs, actions, and outputs for each of the process steps are shown in Appendix E.9 with the representative quote or reference to a document. Utilising the data found in the coding, an overview of the process was created. Figure 8-3 illustrates the critical process. Finally, following the overview, a narrative describes the process with associated quotes to provide a richer understanding of the case study.

Figure 8-2: Overview of the Insight Discovery Process for Barricade



Source: Author

8.3.2.2 Narrative for Insight Discovery Process Framework for Barricade

Understanding the Unmet Need. The innovation team started investigating a sensor technology to see if a strain gauge could be attached to the trauma plate in situ so that real-time data could be captured on fracture healing. The technology is unique; to the team's knowledge, there are no other similar technologies in the market. The innovation project had limited customer engagement, and much of the front end effort was dedicated to solving the fundamental technology issues. Therefore, the team did not conduct observations of surgeries or interviews with surgeons. The main technology challenges included bonding and protecting the sensors on the plate, powering the sensors, retrieval of data from the sensors, and how the data was fed back to the surgeon for visualisation and decision-making. The team understood these design challenges and organised around solving these step-by-step, starting with the up-steam fundamentals of the technology and working down through the patient wearable, surgeon and patient involvement and development software and the user interface (UI).

Technology Development. Due to the technology issues, the Lead Engineer (C3-I3) spoke about how this project was insulated from the core business decisions. A small budget was allocated to the team without the project being pressured to show progress or a viable business case. *"I think finding the right way to shelter that is vitally important. And then I think having a leader that's willing to champion the project and fight for it. I think especially in bigger companies driving front end and innovation forward is a systemic problem of continuity of focus and continuity of leadership"* (C3-I3). The team partnered with an external sensor company to investigate both the sensors and the data process. A feasibility concept was created with the external partner. This was then reviewed through brainstorming and workshops to produce a list of questions.

Engaging with Customers. Once the technology issues had been resolved, the team started to engage customers to identify their needs. The team began with understanding the surgical process - how the existing instrument kit would be impacted, the development of the patient reader, and the surgeon and patient UI. They used procedural mapping to understand how each step was currently performed and how this would change. This task was complex as this product spans the surgeon operating, the nurses activating the device, and the patient transmitting the data from home. Qualitative market research was

conducted with all these customer groups (C3-D2). The customer needs were difficult to define as this product will be new to the market (C3-D1). There is no primary research into what constitutes good fracture healing, so understanding what data was to be collected and provided was problematic. It was acknowledged that quantitative research within an emerging technology would not give them the data required to advance their knowledge.

Discovering Customer Insights. Various insights were discovered as the technology matured, and the team spoke with surgeons and patients. One such customer insight was that the team realised that surgeons were required to be educated in bone fracture biomechanics and plate performance so they could understand the data. The surgeons only received a basic grounding in biomechanics at university, so the team were required to build an educational platform around the product. This also led to the team being challenged on what type of data to display to surgeons or patients, for example, what data would provide benefits and drive decision-making. After exploring ideas, a dashboard for the patient was created to show good or bad healing, and the surgeon obtained a more detailed graphical view. At a design meeting, when the surgeons were reviewing the prototype, another pathway the surgeons explored was – what other data and research could be accomplished in the future:

> *"I think what it informs is two things. I think one is that we initially were going to redisplay this information. Here's the information. There was a keen desire for them to, if you will, mess around or change the different views of the data to better understand because this is a new territory for them. Number one and then number two, there is this desire to publish right, which you know. But when you have these new areas of science, it reinvigorates this desire to publish. So, the whole discussion now with the research mode to the software is things that are not, you know, we don't know what they mean. We have a temperature sensor on the sensor as well. Outside of strain, we don't know what temperature means, but if you enter the research mode, you get visibility to the data. We have no idea what it means, and we're not going to make any statements about it. But how can we change our approach in the market in a compliant way to give information to clinicians to power them to do their studies? We don't have to be the cornerstone*

of our publications, but how can we give them access to the data so they can make their own discoveries around our data?" (C3-I2).

Though not precisely an insight, the Marketing Director (C3-I2) was able to resolve the business case. Initially, the company could not increase the price for the smart plate from a standard plate as they were required to show a clinical advantage. However, in the previous year, the telemedicine market had shifted (partially due to COVID-19) and having patients not return to the hospital is now seen as an advantage for new technology. This has led the US FDA to create a new therapeutic remote monitor billing code so hospitals can bill for using a smart plate (C3-D1). This change in the market significantly improved the business case for the device and gave the project more focus and budget from senior management.

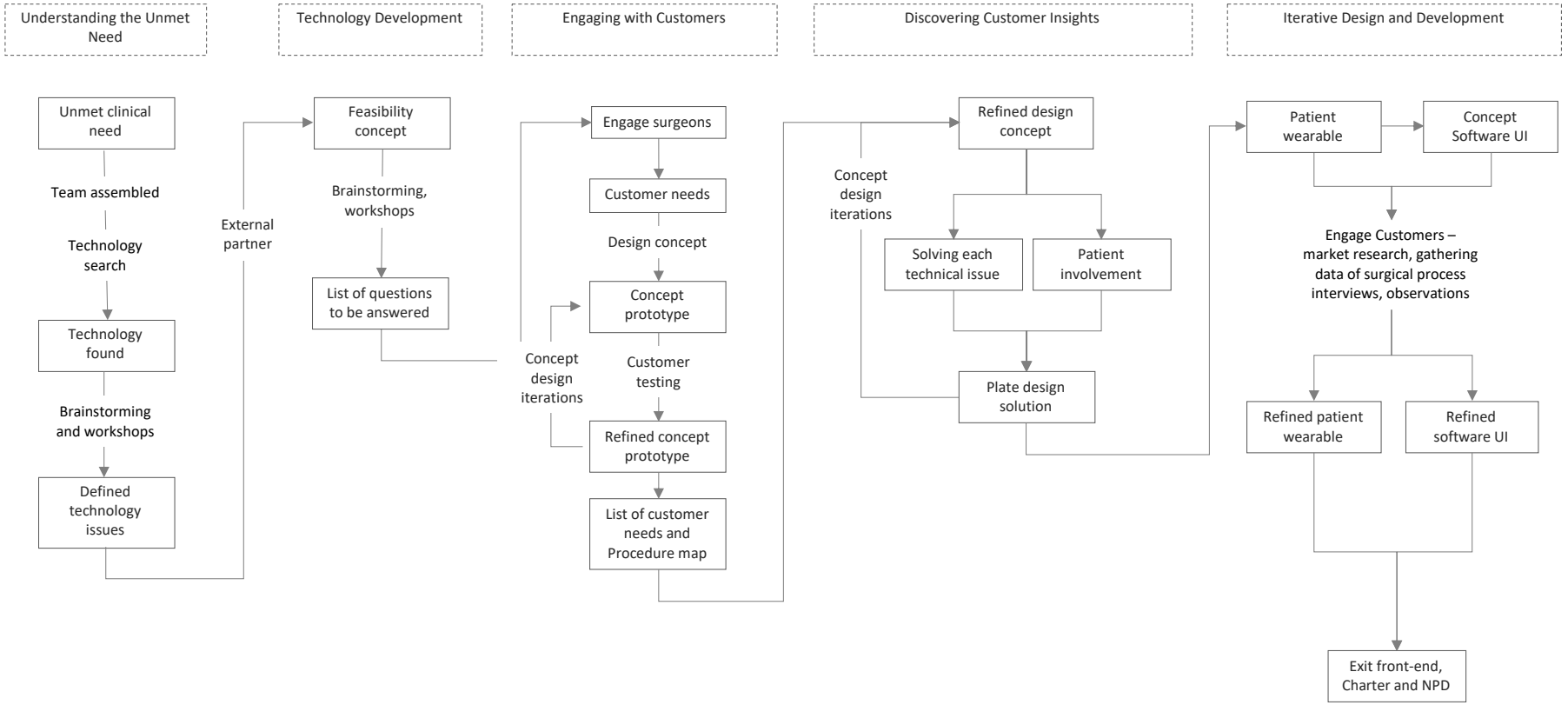
Iterative Design and Development. Once the plate design was complete, the team turned to the development of the patient wearable, the device that would read the data from the plate. The Lead Engineer stated, *"we started off with the basic concept of the plate itself. And now comes the part where we need the customer insight because we're currently developing the patient wearable"* (C3-I1). The concept went through multiple design iterations. The team conducted usability testing with all the customers - surgeons, nurses, and patients (C3-D3). The iterations of the concept reached a point where the team decided to conclude the FEI and advance to the NPD stage (CX-D1).

8.3.2.3 Summary of the Barricade Project

In summary, the brief overview showed that the team were able to resolve the technical issues with the concept design and moved into the design aspect that required human interfaces. When engaging with the customer, the team were able to discover unique customer insights that assisted them in building their user needs; these are captured in the RTM document (C3-D3). The customer drove the customer insight (education on stress/strain) and evaluated the concept, particularly the UX design concept. They are planning to develop an education program to address the stress/strain knowledge gap. They continued to engage the customer throughout the front end process to understand their issues, obtain answers to questions, and test ideas and prototypes. Figure 8-3: Framework for the Insight Process for Barricade illustrates the process the team went through for the case study. Also, refer to Appendix E.7, the first- and second-order

analysis. Appendix E.9 provides the practices and elements that the insight moment process is based upon.

Figure 8-3: Framework for the Insight Process for Barricade



Source: Author; based on Appendix E.9

8.4 OVERVIEW OF THE AMALGAM CASE STUDY 4

The Amalgam project is a product innovation within the orthopaedic joint reconstruction business unit. The business unit specialises in hip and knee arthroplasty medical devices. The marketing and R&D functions are in the UK and USA. Amalgam is a new unicompartmental knee system that uses minimally invasive surgical technology to implant the knee prosthesis. A knee has two compartments (medial and lateral); a total knee replacement would resurface both compartments. Whereas a unicompartmental knee only resurfaces one compartment, typically the medial compartment. A unicompartmental knee is less invasive and is typically used on younger patients.

8.4.1 Data Collection for Amalgam

Data collection was conducted in January and April 2022. The data sources consisted of interviews and company documents.

8.4.1.1 Interviews

The four semi-structured interviews were drawn from marketing and R&D functions. Details of the participant's role and responsibility, interview duration, and date are shown in Table 8-5. The total duration of the interviews was just under 2 hours 49 minutes, an average of 42 minutes per interview.

Table 8-5: Interview Details for Amalgam

Interview Number	Role, Job Title	Case Participant	Experience in NPD	Date	Interview Duration (min.sec)
1	Engineer	C4-I1	12 years' total experience	January 2022	45.59
2	Industrial Designer	C4-I2	2 years in current business 19 years' experience	January 2022	42.45
3	Industrial Designer	C4-I3	6 years' total experience	January 2022	50.07

4	Marketing Director	C4-I4	5 years' total experience	April 2022	31.17
				Total	169.28

Source Author

8.4.1.2 Documents

Four relevant project documents were collected from the interviewees during the interview. Table 8-6 lists the documents.

Table 8-6: Document Details for Amalgam

Document Number	Title	Document Content	Number of Pages	Date	Author
C4-D1	Instruments User Needs and Intended Uses Report	Lists the user needs for the project	15	June 2020	Lead engineer
C4-D2	VOC summary presentation	Provides the VOC research data	105	January 2019	Marketing Manager, Lead engineer
C4-I3	Design Control Procedure	Gives the process guideline on FE and NPD	8	June 2020	Business Unit
Cx-D1	Cadence stage-gate guidance v11	Instruction on the Cadence stage-gate process & overview slide	25	October 2021	Business Unit

Source: Author

8.4.2 The Insight Discovery Process

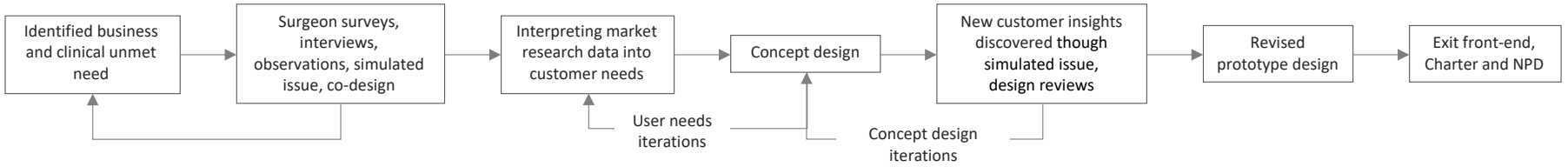
8.4.2.1 Coding and Process Framework

The interviews covered the participant's experience through the FEI with this specific project; the interviews explored the crucial process steps, activities, and outputs in the process. The first-order coding generated 26 codes; these were then aggregated into five second-order codes. The aggregated second-order codes revealed that the team pursued five process steps through the FEI: understanding the unmet need, engaging with

customers, understanding the customer needs, discovering customer insights, and iterative design and development. The coding of the interviews also revealed the inputs, actions, and outputs for each of the process steps. To demonstrate the validity of the coding, Appendix F.7 provides the coding structure with representative quotes, and Appendix F.8 shows the data structure.

The inputs, actions, and outputs for each of the process steps are shown in Appendix F.9 with the representative quote or reference to a document. Utilising the data found in the coding, an overview of the process was created; as such, Figure 8-4 illustrates the team's process for the Amalgam project. Finally, following the overview, a narrative describes the process with associated quotes to provide a richer understanding of the case study.

Figure 8-4: Overview of the Insight Discovery Process for Amalgam



Source: Author

8.4.2.2 Narrative for Insight Discovery Process Framework for Amalgam

Understanding the Unmet Need: The unmet need for the project was clear from the outset; the team were required to develop a new unicompartmental knee system that addressed mobile and fixed bearing philosophies with a single system (C4-D1). A competitor had a very successful product that had a 50% market share; the business unit had an existing product, but it needed to be competitive. Therefore, the unmet business need was to develop a superior product. With the establishment of the business need and clinical unmet need, the marketing team engaged in market research to gain a general understanding of the market. This work led to a refined unmet clinical need.

Engaging with Customers: Customer engagement activities included questionnaires given to customers that asked about existing devices; they also interviewed over 200 surgeons at conferences. They found that the market was split into two types of users, *"you've got the guys we've got doing them all the time, whereas we know the majority of them are doing five to ten a year*" (C4-I3). After the broad market research, the team began working with a smaller group of design surgeons. They observed surgeries and conducted simulated benchtop usability labs, cognitive walkthroughs, diary keeping, and contextual enquiry (C4-D2). They also co-created with the users, examining the existing devices (C4-D2). The Industrial Designer (C4-I2) summarised these activities, *"we really do need to use the ability to grasp what the end user really thinks and document that"*. These engagement activities culminated in the generation of a list of issues (C4-D1). However, the Engineer did state that they had issues with finding customers, *"we really struggled to get access to surgeons to be able just to have a conversation with them. We went to a conference specifically to try to glean user information and gather some of the feedback on existing cases. And unfortunately, nobody wanted to come and talk to us. We sat in a room for several hours waiting for people to come"* (C4-I1).

Understanding the Customer Needs: The team looked at the market research data they had gathered and started to interpret the data into customer needs. This step consisted of activities such as brainstorming sessions, breaking the surgical procedure down into smaller tasks, aligning the issues with each step, and matching the customer statement with observations. From this, the team validated what they found from reviewing the videos and interview transcripts. The output was the Instruments User Needs and

Intended Uses Report (C4-D1), which led to the development of a number of initial concept designs to validate the needs further. The Industrial Designer commented that there was a requirement to continuously check back to the report as they progressed to ensure they had not drifted, *"check-ins with what your needs help along the process. I think sometimes we generate them at the beginning, and they stay there, whereas if you continuously pull them through, you've got things like Task and Use Analysis that you can go into and make sure you're mitigating against those, or you've got a track of why you've done it*" (C4-I3).

Discovering Customer Insights: During the interpretation of customer needs, the team discovered crucial insights. The first insight was that they realised that two different surgical approaches could be combined into a single instrumentation system; this discovery significantly decreased the complexity for the users and improved business efficiency. This was discovered through observation of many surgeons' workflows. The other insight moments the participants discussed were technical solutions that they had been struggling to resolve. The participants spoke about how they conducted 'heaven and hell' sessions with the prototypes to see where they could improve; this led to small insights into the surgical process. The Lead Engineer (C4-I1) stated, "*there was a difference. It was a definite feeling. This delivers what we want to deliver, gives improvements, gives efficiencies. Gives a more stable platform for further cuts and further preparation".*

Iterative design and development: The final steps in the FEI were a process of iterative prototype development. This involved multiple simulated uses with design surgeons; at each iteration, the prototype concepts were refined and retested. Once they were satisfied, the final concept was reached, and the team finalised the user needs (C3-D2) and moved into the Cadence charter gate and onto NPD (CX-D1).

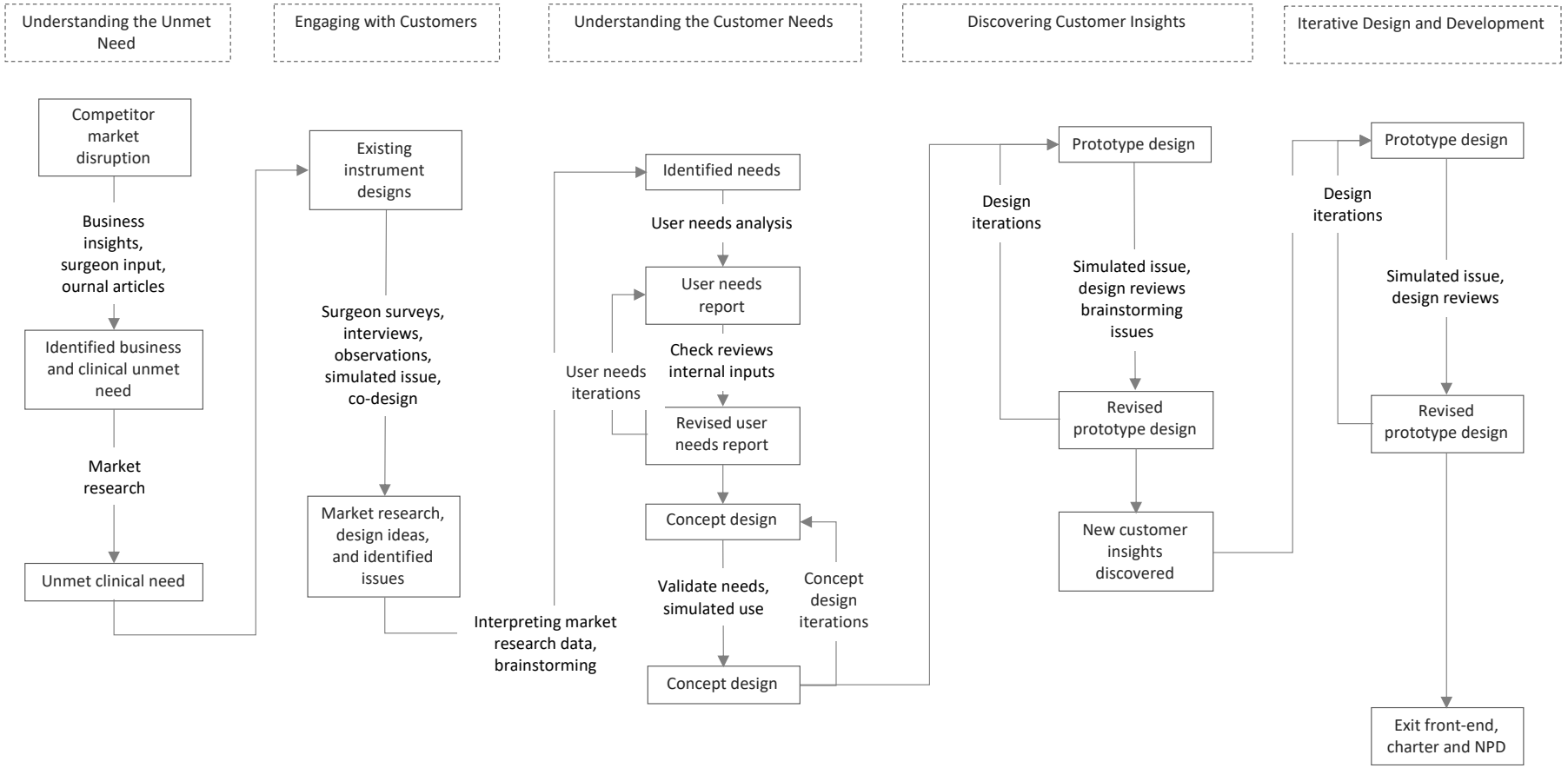
8.4.2.3 Summary of the Amalgam Project

In summary, engaging with customers and understanding their needs were overlapping and iterative; there was the initial general understanding of the customer issues, and then, as the team dug deeper, the issues and questions became more specific. They collected data and then interpreted it to uncover needs, and then, in collecting more data, the insights were discovered. In the combined surgical approach, customer insight was

discovered through observing surgeries and analysing the surgical process. This insight was incorporated into the surgical instrument designs. The other insights were discovered during the process of iterating prototype design concepts.

The discovery of the customer insight process described above was revealed through the coding of the elements and practices the team undertook in the front end. Appendix F.9 provides the practices and elements for the insight moment process shown below, as well as the associated participant quote and reference to the documents. Figure 8-5 illustrates the process the team went through for the case study. The overall process steps are shown in the dotted line boxes, the inputs and outputs are in the solid line boxes, and the practices are shown by overlaying of the arrows. Also, refer to Appendix F.7 for the first- and second-order analysis.

Figure 8-5: Framework for the Insight Process for Amalgam



Source: Author; based on Appendix F.9

8.5 OVERVIEW OF THE MINERVA CASE STUDY 5

The Minerva project is a product innovation within the digital imaging surgery business unit. The marketing and R&D functions are in Ohio, USA. The project is a laparoscopic visualisation video system that incorporates high-definition colour video with new imaging technologies that allow surgeons to detect critical structures that they would otherwise not be able to see or localise. This advanced visualisation allows the surgeon to visualise the anatomy still as they would with a laparoscope and perform a procedure. It also has augmented video capabilities that overlay the anatomical structures.

8.5.1 Data Collection for Minerva

Data collection was conducted in February and March 2022. The data sources consisted of interviews and company documents.

8.5.1.1 Interviews

The four semi-structured interviews were drawn from marketing and R&D functions. Details of the participant's role and responsibility, interview duration, and date are shown in Table 8-7. The total duration of the interviews was 2 hours 35 minutes, averaging 39 minutes per interview.

Table 8-7: Interview Details for Minerva

Interview Number	Role, Job Title	Case Participant	Experience in NPD	Date	Interview Duration (min.sec)
1	Lead Engineer	C5-I1	4 years in current business 19 years' experience	February 2022	45.02
2	Industrial Designer	C5-I2	5 years in current business 10 years' experience	February 2022	50.30
3	Project Manager	C5-I3	10 years' total experience.	February 2022	24.44
4	Marketing Director	C5-I4	5 years in current business 15 years' experience	March 2022	35.14
				Total	154.90

Source: Author

8.5.1.2 Documents

Three relevant project documents were collected from the interviewees during the interview. Table 8-8 lists the documents.

Table 8-8: Document Details for Minerva

Document Number	Title	Document Content	Number of Pages	Date	Author
C5-D1	Target product Profile (TTP)	Marketing strategy and Business case; Clinical benefits; value proposition	19	May 2021	Marketing Manager, Lead Engineer
C5-D2	Customer Input Requirements	Describes the Customer Input Requirements (CIRs) associated with the development of the Laparoscopic Visualisation	12	Novemb er 2022	Lead Engineer
Cx-D1	Cadence stage-gate guidance v11	Instruction on the Cadence stage-gate process and overview slide	25	October 2021	Business Unit

Source: Author

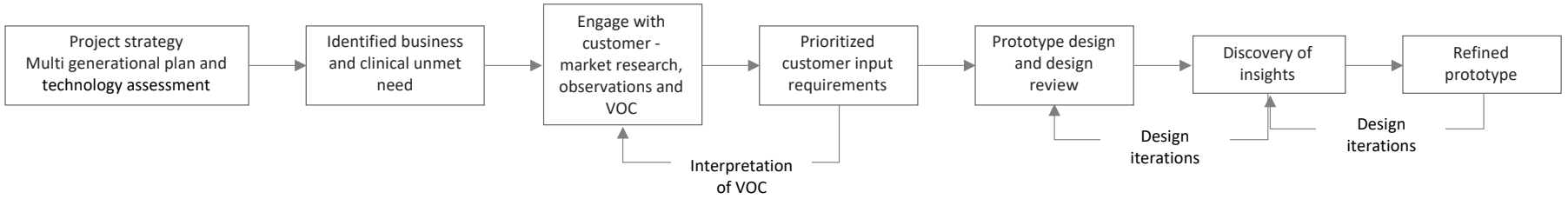
8.5.2 The Insight Discovery Process

8.5.2.1 Coding and Process Framework

The first-order coding generated 31 codes; these were then aggregated into six second-order codes. The aggregated second-order codes revealed that the team pursued six process steps through the FEI: project strategy, understanding the unmet need, engaging with customers, understanding customer needs, discovering customer insights, and iterative design and development. Furthermore, the coding of the interviews also revealed the inputs, actions, and outputs for each of the process steps. To demonstrate the validity of the coding, Appendix G.7 provides the coding structure with representative quotes, and Appendix G.8 shows the data structure.

The inputs, actions, and outputs for each of the process steps are shown in Appendix G.9 with the representative quote or reference to a document. Utilising the data found in the coding, an overview of the process was created, as such Figure 8-6 illustrates the team's process. Finally, following the overview, a narrative describes the process with associated quotes to provide a richer understanding of the case study.

Figure 8-6: Overview of the Insight Discovery Process for Minerva



Source: Author

8.5.2.2 Narrative for Insight Discovery Process Framework for Minerva

Project Strategy. The project started with a strategic direction to provide an enhanced laparoscopic visualisation system. The medical imaging market was shifting from image only to data and image. The marketing team initially created a multi-generational platform plan (MGP) that described how the organisation would develop the products that would incorporate the platform technology and address the various surgical applications. Working with technology experts and high-level surgeons, the MGP provided a strategic direction and outlined the unmet clinical needs and business needs. The first project outlined by the MGP was laparoscopic imaging.

Understanding the Unmet Need. An innovation team investigated the unmet clinical and business needs (C5-D1) by engaging customers. This involved understanding how to improve outcomes and how visualisation could improve the surgical experience.

Engaging with Customers. To investigate the unmet need, the marketing function did a significant amount of market research, "*300, 400ish objects of VOC*" (C5-I1). Objects were defined as statements from the customer. Listening to the critical opinions of leading surgeons, marketing, and R&D gather needs and the customer's "*vernacular*". It was acknowledged by the Marketing Director (C5-I3) that most users would be less skilled and experienced than the surgeons who took part in the VOC, *"I would highly recommend that teams don't get caught in that forward sort of trap of going after very highly skilled, highly knowledgeable, and highly regarded folks because the feedback that you're going to get from that group of users is probably very concise, almost polished*". Through the VOC work, the team identified that the customer groups also included other people who touched the product, such as nursing staff and technicians. The step of engaging the customers produced a list of VOC statements that could then be analysed into customer needs (C5-D2).

Understanding Customer Needs. The team met regularly to review, interpret, and translate the VOC into need statements. They described this process as very circular and iterative, *"data and distilling it down into something that we can interpret, something that we can quantify and then something that we can then put into a product is a pretty intense effort, especially in a system like this that we're building from scratch"* (C5-I3). They found their interpretation of the needs evolved as they started to create prototypes

and put them in the hands of the surgeons (C5-D2). To understand the needs, the team immersed themselves in the problem; this was done through observations of laparoscopic surgeries, interviewing surgeons, and analysing the environment (contextual enquiry). A source of needs was identified, "*very critical inputs actually come by way of non-traditional means, either by internal stakeholders that are maybe close to commercial applications or folks that have experience with devices, maybe engineers who are on different project teams. This can actually land what, in some cases, becomes differentiating features that we deliver" (C5-I3).* In parallel to interpreting the needs, the team also evaluated various technology companies to see if they could incorporate the technology to satisfy the customer needs.

They found it challenging to create and validate a prioritised list of needs upfront. They realised that they had to start idea generation and prototyping to understand what they could deliver and so what needs they could address. They were also challenged by senior management to define the MVP; again, they were required to start the design process to find the acceptable lower limits for a viable product. They also found needs that were conflicting and could not be addressed. For example, the surgeons wanted a smaller scope; however, the new imaging technology dictated its minimum diameter size. As such, the smaller scope needed to be abandoned.

Discovering Customer Insights. Some customer insights were discovered from watching the surgeries being performed and seeing the pain points. An insight came from a minor measurement function that had been built into the prototype, but the team had yet to realise the utility it provided to the users. The Lead Engineer explained, *"when surgeons want to make measurements intra-operatively, there are not many good ways to do it. They have to guesstimate how big something is. They could look, for example, at an instrument that's in there, and they know that instrument about two inches long, so I'm going to hold it up near this defect"* (C5-I1). With the new visualisation technology, they can measure the screen with the built-in measurement software. This deeper understanding led to other applications in cancer care that had not yet been considered.

Another insight was that the technology sometimes got in the way; the prototype projected the augmented video all the time. Through testing the prototype, the surgeons asked if they could have the ability to turn it off; they saw it as a nuisance. At critical

points during the surgery, the surgeon wanted total focus; they needed a clear view and did not want any images or data obstructing their view. Once they knew where the critical structures were located, the image was 'captured' in their mind's eye and did not need to be permanently projected on the glasses. Other insight moments came from using the prototype, such as the ability to orient themselves (horizon control) in the surgical space using the scope and the ability for the camera light to be dimmed when it exited the cavity so as not to 'blind' the OR staff.

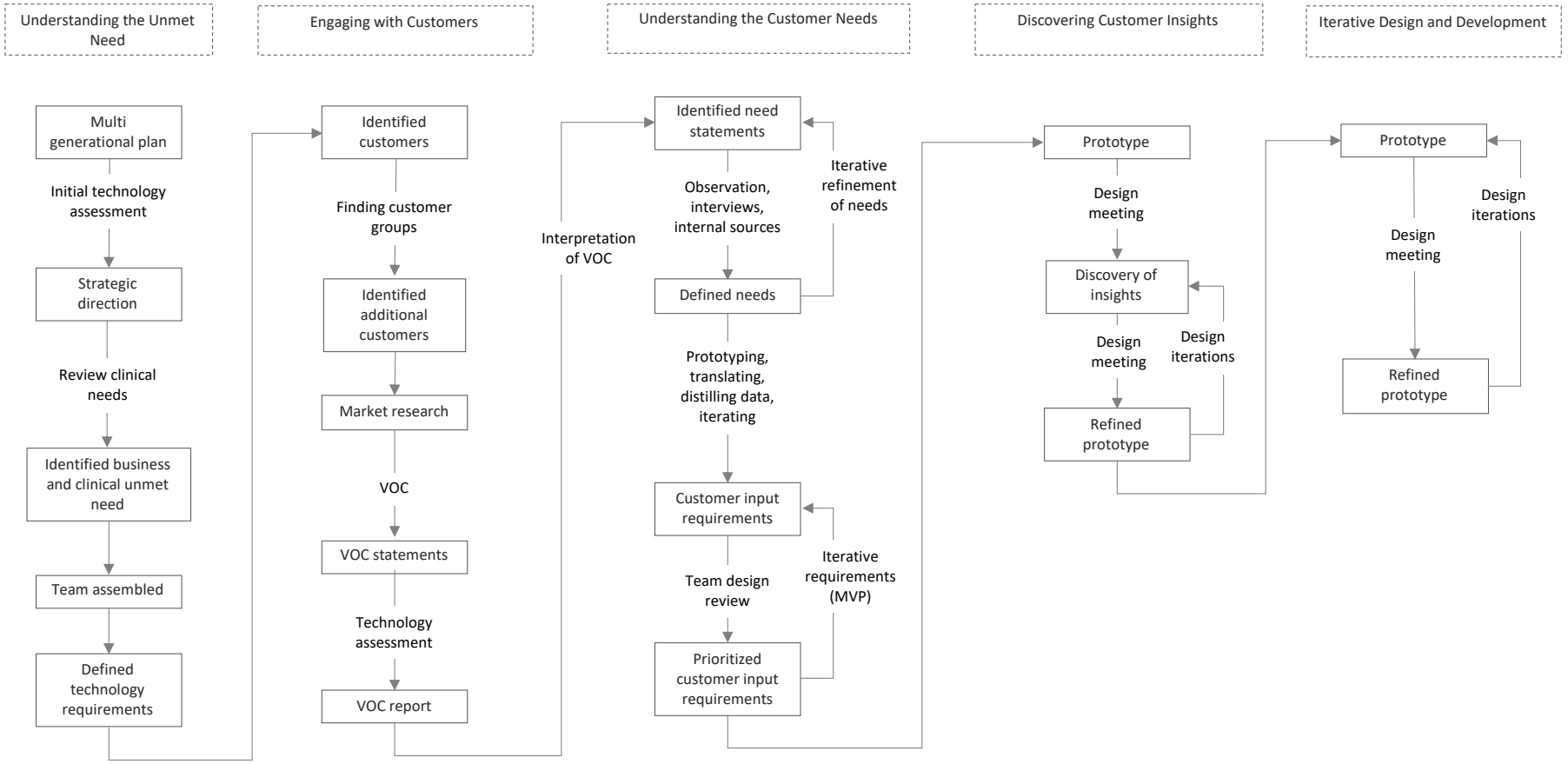
Iterative Design and Development. The final stage in the front end process was the iterations and refinement of the prototype. Each step involved increasing the fidelity of the prototype but also ensuring that the device was simple enough with added features and functions.

8.5.2.3 Summary of the Minerva Project

In summary, the team focused on the unmet clinical need, conducted extensive market research, and proceeded to develop the prototype based on the initial understanding from the market research. Through the development of a prototype, they were able to understand the needs better and discover insights. The insights in the project all came from the customers using the prototype design and the team iterating the design based on insights. They engaged the customer throughout the front end process to understand their issues, obtained answers to questions, and tested ideas and prototypes.

The discovery of the customer insight process described above was revealed through the coding of the elements and practices the team undertook in the front end. Appendix G.9 provides the practices and elements for the insight moment process shown below and the associated participant quote and reference to the documents. Figure 8-7 illustrates the process the team went through for the case study. The overall process steps are shown in the dotted line boxes, the inputs and outputs are in the solid line boxes, and the practices are shown by overlaying the arrows. Also, refer to Appendix G.7, the first- and second-order analysis.

Figure 8-7: Framework for the Insight Process for Minerva



Source: Author; based on Appendix G.9

8.6 SUMMARY

This chapter presented the findings that address RQ 2: *How does the process of discovering customer insights unfold within innovation teams?* The analysis was based on interviews and documents and showed the insight discovery process that the teams followed for the case study innovation projects. The four case studies in this chapter cover four different innovation projects: a linear stapler for bowel surgery, an orthopaedic trauma plate, a unicompartmental knee replacement instrument system, and a laparoscopic imaging system.

As discussed in Chapter 4, these four retrospective cases were selected because, firstly, the research was constrained by time. Secondly, it is difficult for cases to be chosen randomly, as the choice of each case study will attempt to predict similar results (literal replication). Thirdly, access to sensitive and confidential company data on product innovations prohibits random samples from being selected. Therefore, deliberate case selection and theoretical sampling have been utilised. The literature review showed that most previous empirical studies involved multiple case studies and were retrospective.

The second-order coding for the four retrospective case studies in this chapter was informed by the second-order coding from the first case study reported in Chapter 6. This was an iterative research approach, which involved 'simultaneous data collection and analysis, adopting comparative methods, and checking and elaborating' (Denzin and Lincoln, 2011, p. 360). It also involved comparing different levels of data, iterating, analysing, and building a theory as the codes and concepts developed. The process was used as it begins with specific empirical data and builds towards a generalisable theory (Symon and Cassell, 2012). This process has been used with the longitudinal case study report (Chapter 9) and has assisted with the cross-case analysis.

The four case studies presented in this chapter all discovered insights:

- Archway discovered two insights. Finding that they needed a one-handed operation. The force-to-fire was too high on the prototype; in solving this design issue, the team discovered a better overall design solution. Thus, one insight was driven by the customer and the other by a design insight.

- Barricade discovered one insight. The customer insight (education on stress/strain) was driven by the customer engaging in the concept. Also, the team were investigating the dashboard design for the patient and surgeon data.
- Amalgam discovers one insight. The combined surgical approaches to customer insight were discovered through observing surgeries and analysing the surgical process.
- Minerva discovered two customer insights. The first came from the customers using the prototype design, who found that the measuring function provided a lot more utility than initially thought. The second insight came from also using the design concept, and the surgeon found that the technology became a nuisance and obstructed their view of the surgical site. The team iterated the design concept based on these design concept insights.

The discussion in the chapter, with the associated tables and process figures for each of the case studies, showed that there are similarities and differences between each of the projects. The similarities include the high-level approach to the FEI, including practices such as identifying and understanding the unmet clinical and business needs, engaging with customers, iterative design concepts, and prototyping to uncover the need and discover insights. The differences occur at a lower level with the actions the teams undertook to meet the higher-level practices. This will be discussed further in the cross-case analysis in Chapter 10.

CHAPTER 9 FINDINGS FOR THE LONGITUDINAL CASE STUDIES

9.1 INTRODUCTION

This chapter reviews the findings for the four longitudinal cases for RQ 2: *How does the process of discovering customer insights unfold within innovation teams?* Chapter 10 will discuss the cross-case analysis of both the retrospective and longitudinal cases. The analysis was based on interviews and documents and will show the insight discovery process that the teams followed for their projects. The four longitudinal cases were called – Projects Plexus, Stanley, Violet and Planetary. In addition, the chapter includes the case study background information, data collected and high-level findings. All case studies were selected as they were actively developing new products and working with customers, and the researcher was granted access. The case studies are also within a US multinational medical company, MedDevCo, which employs over 80,000 people worldwide with more than $50 billion in revenue and produces pharmaceuticals, medical devices, and consumer healthcare products.

The research aimed to understand how customer needs are related to customer insights and the process for the discovery of customer insights. As such, the research was dependent on a customer insight emerging during the FEI. For each case, there were three points in time for the interviews; this allowed data to be collected as the team advanced through the front end and time-bound the data collection; refer to Section 4.5.2 for further explanation.

The participants were selected for the research because the innovation projects were their primary job responsibility during this time. Appendix L.1 provides a complete list of longitudinal case study participants. Other people also worked on the project on an ad-hoc basis but were not included in the data collection. The project leader provided the names of the participants for each project. Access to the interviewees was achieved by contacting the team members through the company email system. Then, if the interviewee agreed that they had the time and confirmed they had experience with the innovative project, a meeting was set up. Consent to be interviewed and agreement of confidentially were established in the email. At the commencement of the interview, the researcher

stated confidentially and anonymity and recorded a verbal agreement. The interview recordings were transcribed using the auto-transcription service in the NVivo software; after the auto-transcribe, the researcher proofed the transcript by listening to the recording and changing any transcription errors.

The second-order coding for the four case studies in this chapter has been informed by the second-order coding from the first case study reported in Chapter 6 and the retrospective cases from Chapter 8. This was an iterative research approach, which involved 'simultaneous data collection and analysis, adopting comparative methods, and checking and elaborating' (Denzin and Lincoln, 2011, p. 360). As such, the second-order codes utilise similar titles as Chapters 6 and 8, which will aid in the cross-case analysis in Chapter 10.

Chapter 9 is organised as follows:

- Overview of Project Plexus case study
- Overview of Project Stanley case study
- Overview of Project Violet case study
- Overview of Project Planetary case study
- Summary of the findings of this chapter

9.2 OVERVIEW OF THE PLEXUS CASE STUDY 6

Project Plexus is a product innovation within the Lung Cancer business unit. The business unit specialises in medical devices and pharmacologic treatments for lung cancer. The marketing and R&D functions are in New Jersey, USA. Plexus is a combination device for the delivery of a cancer drug into the lung. The procedure uses a subcutaneous needle in a syringe to target the cancerous cells with a pharmaceutical. The positioning of the drug in relation to the cancerous cell is critical. As this was a longitudinal study, data were collected at three points during the front end. At the time of the 3rd interview, the project was still progressing through the later stages of the FEI.

1. The 1st interviews were in April 2022.
2. The 2nd interviews were in September and October 2022.

3. The 3rd and final interviews were in January 2023.

9.2.1 Data Collection for Plexus

The data sources consisted of interviews and company documents.

9.2.1.1 Interviews

The semi-structured interviews were drawn from marketing, clinical and R&D functions. For details of the participant's role and responsibility, interview duration, and date, refer to Table 9-1. The total time for all the interviews was 4 hours 46 minutes.

Table 9-1: Interview Details for Plexus

Interview Number	Role, Job Title	Case Reference	Experience in NPD	Interview	Date	Interview Duration (min.sec)
1	Lead Engineer	C6-I1	18 years' total experience in the company	1	April 2022	41.10
				2	October 2022	10.09
				3	Unable to be Interviewed	0.0
2	Clinical Lead	C6-I2	2 years' experience in the company 15 years' total experience	1	April 2022	30.49
				2	September 2022	16.30
				3	January 2023	19.20
3	Clinical Engineer	C6-I3	7 years' total experience in the company	1	April 2022	48.03
				2	September 2022	19.49
				3	January 2023	17.41
4	Marketing Director	C6-I4	16 years' total experience in the company	1	April 2022	36.42
				2	September 2022	24.31

	3	January 2023	23.24
		Total	286 minutes

Source: Author

9.2.1.2 Documents

Three project documents were collected from the interviewees during the interviews. These were documents that the interviewee referred to and authored; Table 9-2 lists the documents. The documents represented the key deliverables of the project. Finally, the Cadence stage gate provided the formal requirements that the team followed.

Table 9-2: Document Details for Plexus

Document Number	Title	Document Content	Number of Pages	Date	Author
C6-D1	Transthoracic-Enabled Intratumoral Drug Delivery Unmet Needs	Full brief on the market research, customer and unmet needs	65	February 2022	External agency
C6-D2	Biodesign Background	Unmet needs and prioritised needs statements	4 slides	June 2022	Marketing Dircetor
Cx-D1	Cadence stage-gate guidance v11	Instruction on the Cadence stage-gate process and overview slide	25	October 2021	Business Unit

Source: Author

9.2.2 The Insight Discovery Process

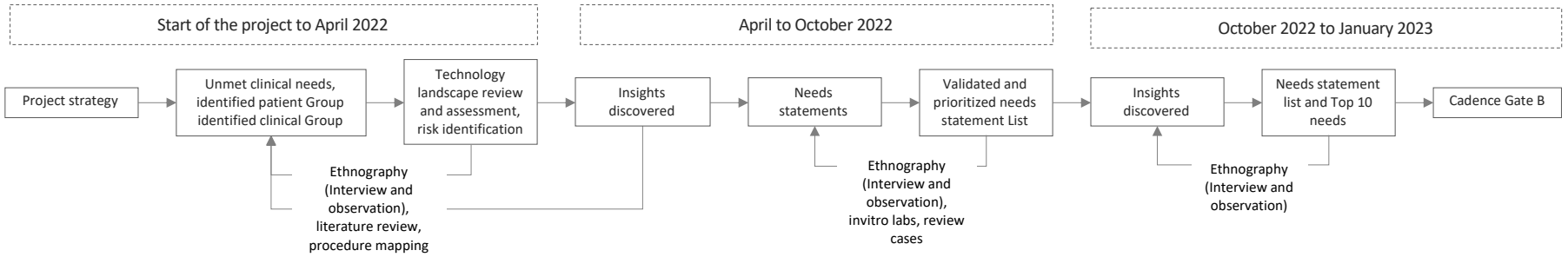
9.2.2.1 Coding and Process Framework

The interviews covered the participant's experience through the FEI with this specific project; the interviews explored the crucial process steps, activities, and outputs in the process. The first-order coding generated:

- 39 codes for the first interview; these were then aggregated into five second-order codes.
- 21 codes for the second interview; these were then aggregated into four second-order codes.
- 19 codes for the third interview; these were then aggregated into three second-order codes.

The aggregated second-order codes revealed that the team pursued seven process steps through the FEI: project strategy, understanding the unmet need, technology development, understanding the customer needs, discovering customer insights, engaging with customers, and iterative design and development. Furthermore, the coding of the interviews also revealed the inputs, actions, and outputs. To demonstrate the validity of the coding, Appendix H.3 provides the coding structure with representative quotes, and Appendix H.2 shows the data structure. Figure 9-1 illustrates the team's process for the project. Finally, following the overview, a narrative describes the process with associated quotes to provide a richer understanding of the case study.

Figure 9-1: Overview of the Insight Discovery Process for Plexus



Source: Author

9.2.2.2 Narrative for Insight Discovery Process Framework for Plexus

9.2.2.2.1 Start of the project in April 2022

Project Strategy. The team discussed the project strategy (C6-D1) and how the project will fit into the existing product portfolio. The team had access to an existing robotic technology from MedDevCo (shown in Figure 9-2) and was tasked to see if the project could build on this technology platform. This was described in the Transthoracic-Enabled Intra-tumoral Drug Delivery document (C6-D1). For example, a key challenge described in the document was, "*for interventional radiologists experienced in the lung, they do not see pneumothorax as the limiting factor to adopting intratumoral drug delivery: it is a risk that is mitigated and managed. But the narrative around pneumothorax creates a perceived barrier to transitioning to the lung for non-experienced proceduralists*". Due to confidentiality, the contents of the document and other more detailed information about the project cannot be shown. However, it was clear the team were not allowing the robotic solution to be the only technology pathway that would be considered, *"so we're still focusing on the robot as kind of a cornerstone and as a flagship of our therapeutic access portfolio, but we are expanding beyond that"* (C6-I2). It was agreed at the beginning of the front end process that the strategy would develop along with their understanding of the surgical procedure, problems, and limitations.

Figure 9-2: Surgical Robotic Platform



Source: Image from MEDDEVCo company website

Understanding the unmet need. The team undertook an exercise to understand the clinical unmet needs for a percutaneous lung cancer procedure (C6-D1). This exercise involved observing and interviewing radiologists and enquiring about their current practice for accessing the lung percutaneously. From this, an end-to-end procedure map was created; this detailed each step and its relative importance (the procedure map was not shared with the researcher). *"I kind of build out procedure maps. Then, a lot of times, I emailed back and forth with some of these users to get questions answered. Talking on the phone with them. Sometimes a little bit informal, sometimes formal and procedure observation."* (C6-I3). The innovation team used the map in an internal meeting to understand the current level of satisfaction, the problems, and the limitations. The team used the map to highlight the opportunities, *"we know the procedure really well. It's just, what are the problems that we need to solve?"* (C6-I3). They were told an analogy; the Clinical Engineer explained, *"One doctor always explained to us that trying to place a needle in a tumour in the lung is like trying to stab a grape in a bowl of jelly"* (C6-I3). After creating the overall procedure map for the surgical process, pharmacy, surgeon, and post-operative maps of the users' and patients' journeys were also created. These maps were used to find the risks to the users and patients. The risk analysis was performed, and a risk assessment document was created to capture the risks (document not collected). The procedure mapping and risk assessment were likened to the Job-Outcome-Constraints process (Ulwick, 2002). The Lead Engineer (C6-I1) described it as:

> *"Whether you call it customer needs or jobs, what individual things does the doctor need to do to check the box and say, I've completed that step? Then, once you have all those laid out, you can say, all right, in terms of the outcomes of the procedure, the desired outcomes, and how important each of those jobs is because some of them are going to be absolutely critical. Some will be maybe kind of nice-to-haves and everything in between".*

To find the unmet needs, the team observed surgeries to gain an appreciation of the challenges that clinicians face. The Lead Engineer (C6-I1) stated, *"what they were attempting to do and what unmet needs they had preventing them from kind of realising their vision".* The market research led the team to discover that two distinct clinician

groups performed the procedure and that this was dependent on the hospital setting - radiologists and pulmonologists (C6-D2). Though primarily a pulmonologist role, in particular hospitals, radiologists are also trained in the procedure. Each customer group had different unmet needs. The Clinical Lead (C6-I2) explained this as *"a better understanding of what it is that they do and what they think they can, or they can't do. Getting to that point of understanding what it really means more than just what you read"*. The team also found which type of patient was best suited to the procedure, as the Clinical Lead (C6-I2) again explained, *"patients are too heterogeneous. There's always lots of variability, becomes too hard to say, 'you're always going to use Tool X to treat problem one'. Just never happens"*.

Technology Development. Taking the procedure maps and the unmet needs, the team then started a technology assessment. Technologies that are currently available were reviewed and matched to the areas on the map to highlight needs that were not well met, *"technology landscaping effort to look at the existing technology*" (C6-I1). This involved exploring technologies internally and externally with partners. The Marketing Director (C6-I4) stated, "*I've been rolling up a lot of these broader unmet needs into a more commercial side where we look at the unmet needs and what technologies might need to be delivered against those unmet needs to deliver the drug into procedurally through a transthoracic access channel. And then it's helping us evaluate whether or not there are some technology gaps within our portfolio that we might want to go after"*.

Understanding the Customer Needs. The team used the procedure maps to identify the customer needs by examining each step. They then used the knowledge they gained to rank these in importance, from critical to nice-to-haves. The team was also aware that the customer's needs were required to be "laddered-up" (C6-I4) into the unmet need. The team consolidated the identified needs to create customer need statements. This also involved validating and prioritising the statements internally and with customers. If a customer disagreed with the statement, they noted it, but the team decided to remove or retain it (C6-D2). The Clinical Engineer (C6-I3) explained the validation discussion as *"where you would go about explaining to them how you came about that statement, so showing them all of the different processes that got there*". During this validation process, they recognised that they were required to explain which customer valued that particular need.

Discovering Customer Insights. The innovation team found two customer insights during the interviews and observations that they conducted. Firstly, the radiologist in the US did not perform many percutaneous procedures and *"somewhat shied away*" (C6-I1). The surgeons considered the procedure risky, so the team were required to determine how radiologists were trained and adapt the training the customer had to reduce the risk. Secondly, the team discovered that the pathway of how patients were referred to a hospital by the general practitioner was complex. The referral pathway decides what type of clinician they would go to and, therefore, what type of procedure they would have. These insights into the perceived risk of the procedure and referral process were flagged to be actioned with new training, and they also fed new needs.

Next steps. The team reported that in the following steps, they would continue to increase their understanding of the "information across the spectrum of procedures" (C6-I2) to understand the risks, benefits, and opportunities and to continue the technology landscaping review.

9.2.2.2.2 April to October 2022

In the three months following the 1st round of interviews, the team developed the project in four areas: project strategy, customer research, internal workshops, and updating the needs. The Marketing Director (C6-I4) summed up the last three months; she stated: *"I think one of my lessons since we last spoke is as we're changing everything, we're learning and adapting and shaping"*.

Project Strategy. The Lead Engineer attended two external technology partner meetings to understand if any available technologies met the identified needs. They were in the process of bringing in a consultant to speed the project up. The team also participated in a training course on the Stanford Biodesign (Yock, Zenios and Brinton, 2015) process to provide them with a better understanding of the front end process and how to write and prioritise the customer needs. The team were experiencing budget tightening, so they had to prioritise what they would focus on.

Engaging with Customers. The Lead Engineer reported (C6-D1) that the customer research was a significant activity undertaken in the previous three months. They conducted a large ethnography study to gain a broader global understanding of how the product is used through its lifecycle in the hospital. This was an extension of a similar

small-scale US study that was conducted in 2021. The team used an outside agency to conduct the study and were receiving weekly reports. The Clinical Engineer (C6-I3) stated that *"instead of waiting for all the results to come in and then reacting, we've been reacting live to all the information. I've been getting live reports at the end of each week as we get the interviews back".* The Clinical Lead (C6-I2) expressed the importance for the team to engage customers,

> *"I think there's maybe a couple of things that I learned that I'm not sure that I really appreciated that much. What we lack is the knowledge to know. Is that important? It's important, and we don't know right now. But if it does become important, if we learn that it's important or maybe we need to identify that, what if you accessed it this way and you happen to be the lateral aspect of the inferior aspect? Is that important? We learned over time that it is important to consider where you access it".*

Iterative Design and Development. In parallel with the discussion on the project strategy and execution of the ethnography study, the team also had internal meetings and workshops. There were three main types. Firstly, a weekly meeting analysed the ethnography study reports to extract any new needs or insights. The second meeting was every six weeks, where clinicians were invited to review mock patient cases and help the team understand the clinical decision-making. The third workshop was an in-depth testing of the drug delivery systems to gain knowledge on how existing systems work and understand their advantages and limitations.

Understanding the Customer Needs. The activities above led the team to update the customer needs (C6-D2). The knowledge they gained also enabled them to prioritise their needs. The Marketing Director explained (C6-I4), *"after we had those meetings a whole bunch went away because there were much simpler ways. We were able to get to our top 10. We created a value calculation where we talked about the cost of the problem, how many patients it might impact, and what, how, and what the likelihood of success is. So, it is a very crude calculation. And then we got to a dollar amount".* At the time of the interview. The Marketing Director was in the process of creating a needs filter to assist in the prioritisation activities. The filter *"just put high, medium, and low and then compared between each of the other customer needs. Usually, you pick one, and that's*

the zero point, and then you compare it. Is it better, or is it worse than this one?". There was still an ongoing debate about the priorities and the filter assumptions.

Next steps. The following steps in the FEI were continuing with the market research and preparing for a clinical study in late 2023.

9.2.2.2.3 October 2022 to January 2023

Discovering Customer Insight. In this interview, the Clinical Engineer (C6-I3) stated that the flexibility in surgery was surprising; there were no country or hospital standards for the procedure, and this created a lot of risks that she was trying to resolve. This insight was discovered by interviewing the different types of users and customers in various hospitals. They recognised that a procedural standard was required to accompany the devices (C6-D1).

Understanding the Customer Needs. During the time of the third interview, the team reviewed the market research data they had collected and continued to define the customer needs and discover customer insights. Writing the user needs statements at this point was reported by the Marketing Director (C6-I4) as "w*e went through the Biodesign process. We had tons of insights and understanding in the team. But then we landed on 200 and funnelled down to 18 top unmet needs. It was awfully painful and also incredibly informative. Because the iterative process of shaping and writing for someone who's not technical with all these technical folks helped me understand a lot more about the procedure and the asset and how it works"*. This process produced a list of prioritised customer needs that the team could move forward into product development and eventual clinical trial (C6-D2).

Project Strategy. Due to the tightening budget towards the end of 2022, planned activities were put on hold. For instance, the consultant contract was shortened, and a lot of the ethnographic research was stopped. Therefore, the team focused on evaluating the data they had already captured and prioritising the need to start shaping the Charter (CX-D1, Gate C).

9.2.2.3 Summary of the Plexus Project

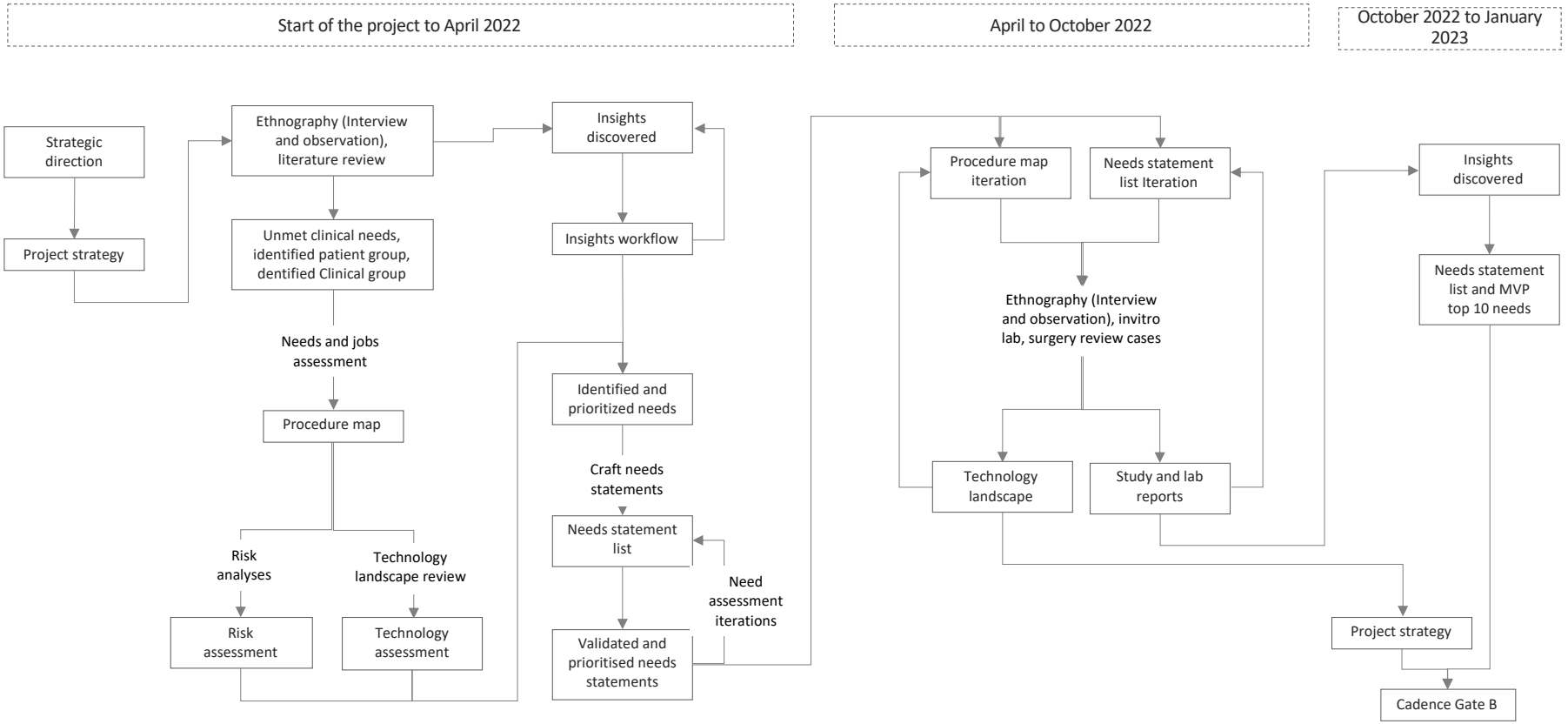
Over the ten months that this project was followed, the innovation team pursued the following activities: 1) ethnographic research studies to uncover the unmet clinical needs,

customer needs and customer insights, and the creation of a procedure map with associated risks, 2) technology landscape review to define which technology would be used to meet the needs, 3) prioritisation and validations of the needs, crafting the needs into needs statements, and 4) and finally defining the scope of the project based on the prioritised needs and technology. The work led to the team defining Cadence Gate A and moving into Cadence Gate B (CX-D1).

The discovered customer insight showed that there was a lot of flexibility in treatment and patient referral and no clear clinical practice or country-specific standards, and this presented an unaddressed opportunity to the team. They found hospitals had suggested guidelines but no defined practice. This insight came from the observations and interviews with the customers that were identified in the procedure map and the risk assessment. The team learned that this project was not just a drug delivery system but also required an educational package and learning journey for customers (analogous to the theory of Diffusion of Innovation (Rogers, 2003)). In the next phase of the project, the team will move into the NPD phase, where they will develop a medical device to deliver the pharmaceutical to the lung (CX-D1).

The discovery of the customer insight process described above was revealed through the coding of the elements and practices the team undertook in the front end. Appendix H.3 provides the practices and elements for the insight moment process shown below and the associated participant quote and reference to the documents. Figure 9-3 illustrates the team's process. The time for each of the activities is shown in the dotted line boxes, the inputs and outputs are in the solid line boxes, and the practices are shown by overlaying the arrows. Also, refer to Appendix H.2 for the first- and second-order analysis.

Figure 9-3: Framework for the Insight Process for Plexus



Source: Author; based on Appendix H.3

9.3 OVERVIEW OF THE STANLEY CASE STUDY 7

Stanley is a product innovation within orthopaedic power tools. The business unit specialises in power tools, such as oscillating saws, reciprocating saws, drills, and reamers. The marketing and R&D functions are in Switzerland. Stanley is the development of a reciprocating saw for unicompartmental knee surgery. As this is a longitudinal study, data was captured at three points during the front end. By the 3rd interview, the project was put on hold.

4. The 1st interviews were in April and May 2022.
5. The 2nd interviews were in August 2022.
6. The 3rd and final interviews were in December 2022 and January 2023.

9.3.1 Data Collection for Stanley

The data sources consisted of interviews and company documents.

9.3.1.1 Interviews

The semi-structured interviews were scheduled in the interviewee's Outlook calendar. The interviewees covered both marketing and R&D functions. Additionally, email communication was used after the interviews to clarify points raised. For details of the participant's role and responsibility, interview duration, and date, refer to Table 9-3. The total time for all the interviews was 3 hours 24 minutes.

Table 9-3: Interview Details for Stanley

Interview number	Role, Job Title	Case Reference	Experience in NPD	Interview	Date	Interview Duration (min.sec)
1	R&D Mechanical Engineer	C7-I1	15 years in the company 23 years in total	1	April 2022	25.48
				2	August 2022	15.55
				3	December 2022	5.44

2	R&D Electrical Engineer	C7-I2	20 years in the company	1	April 2022	49.03
				2	August 2022	27.27
				3	January 2023	8.44
3	Marketing Director	C7-I3	20 years in the company	1	May 2022	29.14
				2	August 2022	35.32
				3	December 2022	8.47
					Total	204 minutes

Source: Author

9.3.1.2 Documents

Three project documents were collected from the interviews. Table 9-2 lists the documents.

Table 9-4: Document Details for Stanley

Document Number	**Title**	**Document Content**	**Number of Pages**	**Date**	**Author**
C7-D1	Target Product Profile (TPP)	Contains the unmet need and strategic direction	18	May 2022	C7-I3
C7-D2	NPD process overview work instruction	Describes the NPD process the team follows	5	June 2020	Business Unit
Cx-D1	Cadence stage-gate guidance v11	Instruction on the Cadence stage-gate process and overview slide	25	October 2021	Business Unit

Source: Author

9.3.2 The Insight Discovery Process

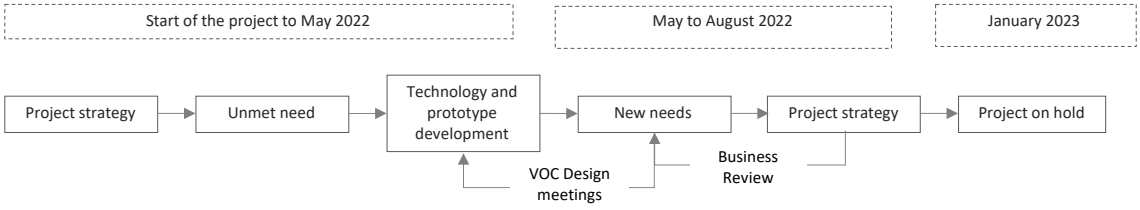
9.3.2.1 Coding and Process Framework

The interviews covered the participant's experience through the FEI with this specific project; the interviews explored the crucial process steps, activities, and outputs in the process. The first-order coding generated:

- 17 codes for the first interviews; these were then aggregated into five second-order codes.
- 8 codes for the second interviews were then aggregated into two second-order codes.

The aggregated second-order codes revealed that the team pursued four process steps through the FE: project strategy, technology development, understanding the customer needs, and engaging with customers. Furthermore, the coding of the interviews also revealed the inputs, actions, and outputs. To demonstrate the validity of the coding, Appendix I.3 provides the coding structure with representative quotes, and Appendix I.2 shows the data structure. Utilising the data found in the coding, an overview of the process was created; as such, Figure 9-4 illustrates the team's process for the project. Finally, following the overview, a narrative describes the process with associated quotes to provide a richer understanding of the case study.

Figure 9-4: Overview of the Insight Discovery Process for Stanley



Source: Author

9.3.2.2 Narrative for Insight Discovery Process Framework for Stanley

9.3.2.2.1 Start of the project to May 2022

Project Strategy and Understanding Unmet Needs. For the Stanley case study, the unmet need was straightforward. The project was a sub-project of a more comprehensive strategic platform (C7-D1). The unmet need was for a power tool for the knee sagittal cut

that fitted onto the Velys orthopaedic robot for unicompartmental knee surgery, *"we need to be able to make a sagittal cut. Our saw today is not able to do it. So, I would say that the basic reason why we need one is fairly obvious and fairly simple honesty"* (C7-I3).

Technology Development. Driven by the unmet need, the team was required to address critical design considerations. Firstly, a fundamental need for robotic surgery was improved accuracy over handheld power tools, *"one of the biggest needs is to have a very good accuracy"* (C7-I1). So, the team investigated new technologies for gearing (gear mating and wear is one cause of inaccuracy) and decreasing the weight of the tool, as a heavy tool, causes more gear wear and more of a moment on the robot arm, leading to further inaccuracy. Another issue was the trigger layout (forward and reverse). The team prepared a few prototypes (see

Figure 9-5 for an image of a prototype) for presentation to the surgical team. Though the robot would be primarily using the power tool, it also had to allow a human to use it; this was a safety feature so that if the robot broke down, the surgery could continue. The team were also trying to resolve how the tool would couple to the robot.

The R&D Electrical Engineer stated experiencing frustration as they would have liked a more structured approach to the development (C7-D2). There were still a lot of unanswered technical questions that were hindering them, *"I like structured approaches. This is what they often miss, or they really like it because it gives you a clear picture at the beginning*" (C7-I2).

Figure 9-5: Stanley Prototype



Source: Author, provided by Interviewee

Understanding the Customer Needs. To identify the needs, the team initially had internal discussions with the other development teams, *"we identified a couple of needs in discussions with all the different teams, but I would say the needs are pretty clear*" (C7-I1). Examples of these precise needs were ergonomic grip, battery capacity, and intuitive attachment (C7-D1). The other aspect that drove the needs was known as reference surgeries; the team were looking across the platforms to understand what type of surgeries the device would be used for in the future so that they could build in this functionality early. The R&D Mechanical Engineer (C7-I1) stated, *"we are talking to all these platform teams and trying to find out in the discussion what surgeries they plan to do. And what is special for these surgeries or what kind of tools they use for these surgeries to get an idea of what's needed for the tool".* They were planning to compile the information into a requirement matrix, *"what we are trying to do in the next couple of weeks is to put together what we have, what you already have and what we already know regarding customer needs"* (C7-I1). In addition, the R&D Electrical Engineer (C7-I2) mentioned he is, *"also thinking about the end user, how he works, participate in surgeries, have a close look I write down some notes, take videos, if possible, to get a really a deep understanding of what the customer really needs, even when he's not able to describe it because he's not aware of the heat".* Though many of the needs were obvious and established early, the team still intended to engage the customers and internal teams further to understand if there were any unique needs or insights.

Engaging the customers. The primary customer engagement activity the team had completed at the time of the interview was a surgeon design meeting in the US. However, the two engineers were not able to attend, so the Marketing Director brought the prototypes to the meeting for review, "*just about ten surgeons, all based in the US. Most of them are already experts*" (C7-I3). At this meeting, they evaluated the prototypes for connection to the robot and the trigger system, "the opportunity was providing some functional samples based on existing products and *exchange of different attachments based on an existing machine system. Is a bit bulky, and it has too much mechanical play between the handpiece and the attachments*" (C7-I2). The feedback on the prototype was positive; they got agreement on the trigger system and the connection feature. The R&D Electrical Engineer stated that at future meetings, *"we hope to get a better picture of what*

they really expect, and maybe also an insight. There are additional possibilities that we did not have in our mind" (C7-I2).

Project progress. The following steps in the project were to develop and test the prototype with a broader surgeon group.

9.3.2.2.2 May to August 2022

Engaging with Customers. The previous three months included the preparation for and attendance at the Boston VOC meeting. At this event, they had four sessions with three surgeons in each session. The surgeons filled in questionnaires, the team demonstrated the prototypes and then had a group discussion. The R&D Mechanical Engineer explained, *"we shared our ideas regarding the overall design. We also showed an idea of how to attach the handpiece to the robot. And everything has a 3D-printed part. This was sufficient to get some feedback from the surgeons because they could feel something in their hand and play with that handpiece"* (C7-I1). The customers identified the same issues that the team had found with the prototype. At the time of the 2nd interviews the team had not yet analysed the data from the meeting, but they had received positive feedback from the prototype, except for the trigger arrangement. They planned to collate and analyse the data in the coming month, then consolidate the customer needs (C7-D1) into a customer requirements matrix, and this is a usual practice.

Project Strategy. At this stage, there was concern from the team that the future of the project was not clear due to budget restrictions and that a leadership meeting was pending in the following month. The next step in the project was to refine the concept design to drive the solving of the questions that still required to be finalised, such as the coupling feature.

9.3.2.2.3 August 2022 to January 2023

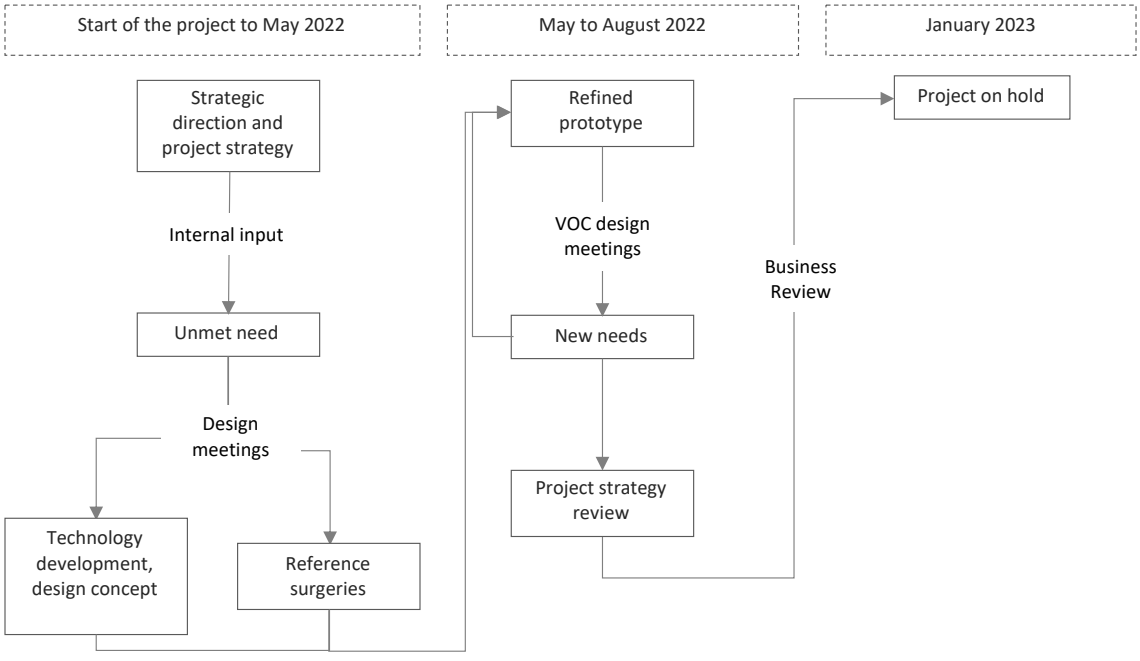
Unfortunately, in November 2022, the project was put on hold, primarily due to budget constraints. As Stanley was a sub-project to a broader platform, it was affected by a change in strategic direction for the business unit. Another reason was that it was not owned by one marketing person; it crossed business units, and no single person was assigned to support it.

9.3.2.3 Summary of the Stanley Project

In summary, the team encountered challenges; as a sub-project, they were required to work within the timelines and scope of the platform project. This hindered their ability to attend meetings and obtain early, timely user input and feedback. This led to the team developing the project from their understanding of the needs. The feedback from the users on the prototype showed that the team were primarily correct in their assumptions. However, the project was put on hold when the business unit re-evaluated the robotic platform strategy.

Consequently, the project could not be followed any further; during the period they were followed, the team were not able to discover any customer insights. The process that was followed is shown in Figure 9-6 below until the project was put on hold. Also refer to Appendix I.2 and the first- and second-order data structure, and Appendix I.3 for practices and elements of the FEI. Though Stanley did not discover any insights, it was included in the research as it does provide data for the initial stages of the FEI that will be incorporated into the cross-case analysis. The implications of the project being put on hold business are outside of this research.

Figure 9-6: Framework for the Insight Process for Stanley



Source: Author; based on Appendix I.3

9.4 OVERVIEW OF THE VIOLET CASE STUDY 8

Violet is a product innovation within the wound care business unit. The marketing and R&D functions are in the USA. Violet is the development of a wound care dressing that has been augmented with sensors that detect infection. As this is a longitudinal study, data was captured at three points during the front end. At the time of the 3rd interview, the project was still progressing through the later stages of the FEI.

7. The 1st interviews were in March 2022.
8. The 2nd interviews were in August 2022.
9. The 3rd and final interviews were in December 2022.

9.4.1 Data Collection for Violet

The data sources consisted of interviews and company documents.

9.4.1.1 Interviews

The semi-structured interviews were scheduled in the interviewee's Outlook calendar. The interviewees covered both marketing and R&D functions. Additionally, email communication was used after the interviews to clarify points raised. For details of the participant's role and responsibility, interview duration, and date, refer to Table 9-5. The total time for all the interviews was 3 hours 24 minutes.

Table 9-5: Interview Details for Violet

Interview Number	Role, Job Title	Case Reference	Experience in NPD	Interview	Date	Interview Duration (min.sec)
1	Principal Scientist	C8-I1	13 years in the company PhD	1	April 2022	31.10
				2	October 2022	24.06
				3	January 2022	20.41
2	Engineering Fellow	C8-I2	15 years in the company	1	April 2022	36.15

			30 years' total experience	2	September 2022	25.03
				3	January 2023	18.21
3	Marketing Director	C8-I3	16 years in the company	1	April 2022	44.56
				2	September 2022	45.31
				3	January 2023	30.11
4	Lead Engineer	C8-I4	7 years in the company PhD	1	April 2022	29.02
				2	No Longer with the company	
				3	No Longer with the company	
					Total	304 minutes

Source: Author

9.4.1.2 Documents Details for Violet

Four project documents were collected from the interviews. Table 9-6 lists the documents.

Table 9-6: Document Details for Violet

Document Number	Title	Document Content	Number of Pages	Date	Author
C8-D1	Unmet needs VOC	Described the unmet need for the project	5	December 2021	Principal Engineer
C8-D2	Purchase Influencer Exploratory	Details user feedback and business environment	40 slides	May 2022	Project Team
C8-D3	Questionnaire	Input sheet for C9-D1	6	January 2022	Project Team
Cx-D1	Cadence stage-gate guidance v11	Instruction on the Cadence stage-gate process and overview slide	25	October 2021	Business Unit

Source: Author

9.4.2 The Insight Discovery Process

9.4.2.1 Coding and Process Framework

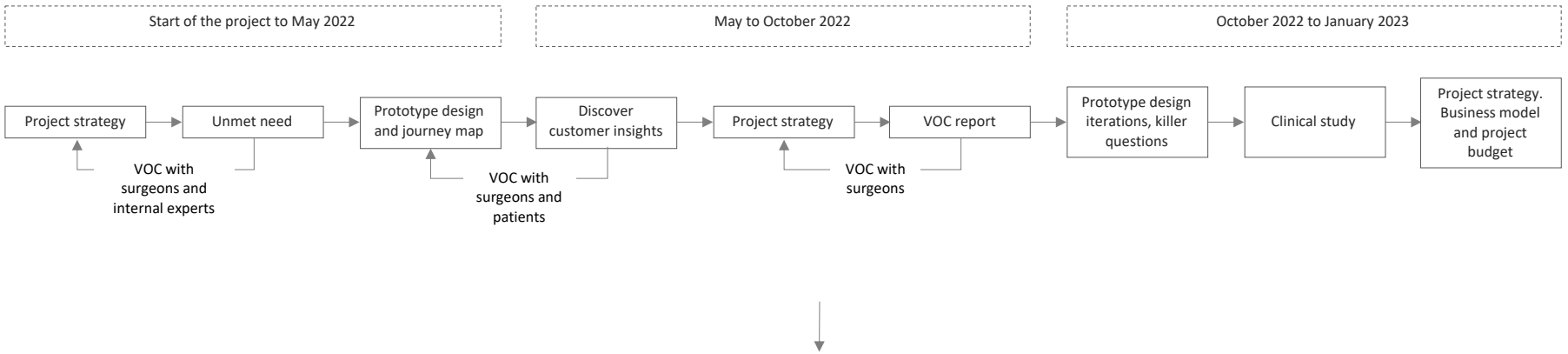
The interviews covered the participant's experience through the FEI with this specific project; the interviews explored the crucial process steps, activities, and outputs in the process. The coding generated:

- 28 first-order for the first interview; these were then aggregated into five second-order codes.
- 10 first-order for the second interview; these were then aggregated into two second-order codes.
- 12 first-order for the third interview; these were then aggregated into three second-order codes.

The aggregated second-order codes revealed that the team pursued five process steps through the FEI: project strategy, understanding the unmet need, engaging with customers, discovering customer insights, and iterative design and development. Furthermore, the coding of the interviews also revealed the inputs, actions, and outputs. To demonstrate the validity of the coding, Appendix J.3 provides the coding structure with representative quotes, and Appendix J.2 shows the data structure. Figure 9-7 illustrates the team's process for the project. Finally, following the overview, a narrative describes the process with associated quotes to provide a richer understanding of the case study.

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Figure 9-7: Overview of the Insight Discovery Process for Violet



Source: Author

9.4.2.2 Narrative for Insight Discovery Process Framework for Violet

9.4.2.2.1 Start of the project to May 2022

In the first interview, five activities were discussed: project strategy, understanding the unmet need, engaging with customers, iterative design and development, and discovering insights.

Project Strategy. Utilising the strategic direction, the Marketing Director (C8-I3) began the project with a product landscape search to determine the current gold standard in the detection of postoperative surgical site infections (C8-D1). He then conducted a clinical review with the company's internal medical doctors; though it was not the same demographic as the product users, it helped to frame the unmet need.

Understanding the Unmet Need. The market research led to the realisation that a digitally enabled wound care device would enable the company to *"extend that umbrella to the patients in their healing period. So, that thought being then, well maybe, we could put something into a wound closure product"* (C8-I2). There was a push by the company for products to move into the digital space, so this project fitted well with the business strategy. The COVID-19 pandemic also showed that there is value in remote monitoring, as patient behaviour changed, and they were less likely to return to the hospital after surgery. Consequently, surgeons were more willing to consider remote treatment options (C8-D1). The device would also be able to show that *"things are going wrong because healing is not happening properly. You could also prevent people from wasting physicians' and nurses' time by providing an accurate diagnosis device"* (C8-I2). They recognised this is a product that would offer immediate value to patients and clinicians. It could also collect long-term data across many patients and provide by predicting wound healing. However, the healthcare data created challenges concerning the collection, storage, sharing, and utilisation of the data. This brought the company's IT managers into the discussion.

Engaging with Customers. The team undertook various actions to engage the customer. As infection is a sensitive subject in surgery, the team initially spoke with surgeons whom they had previously worked with to understand the issues and discover *"how they detect a surgical site infection"* (C8-I3). They specifically engaged orthopaedic surgeons as they are one of the surgical fields that are particularly careful in

preventing infections. The team also spoke with families of patients who had experienced surgical site infections; their "*stories were very different"* than those of the clinicians (C8-I3). As they would be wearing the dressing 24 hours a day, the patients asked very practical questions concerning comfort, convenience, showering, dressing, and bending over. This input led the team to include not only the clinicians' but also the customers' needs from the patients' and carers' perspectives.

Iterative Design and Development. The Principal Engineer (C8-I2) conducted a technology landscape search on sensor modalities. He started by looking through the literature to see which modalities matched the clinical signs of infection and found three that were considered significant. He *"started to work triangulating these three sensor types to have more predictive potential for assisted detection"* (C8-I2). It was also decided that the device should be exterior to the patient, as opposed to subcutaneous. The patients' and the physicians' perspectives were mapped to assist in visualising the product's journey (C8-I4). To better understand the patients' and carers' needs, the Engineering Fellow (C8-I3) took a prototype home to experience using it. Finally, once they had the technology working, they created software mock-ups that displayed the relevant data to the patients and clinicians.

Discovering Customer Insights. Interviewing surgeons revealed that surgical site infections were a problematic area to discuss and gather feedback on; the team found that surgeons disagreed they needed it for their practice and that other surgeons instead needed it, *"go and talk to Dr. So-and-so down the hall. He has a problem"* (C8-I1). Another customer insight was around collecting data and the legal issues that this involved, *"how can this data be used beyond the medical surgical application? In other words, if I, as the surgeon, elect not to do anything based on the data because that is my medical opinion and then later something happens, what are the legal implications and ramifications of my decision?"* (C8-I1). The team were initially surprised by why the value the product could offer was challenged, as the assumption was that data is always good to have. But the surgeon provided a different insight - how the data would change their practice, "*you have to tell me something that is going to change the natural progression of the intervention*". The Lead Engineer expressing this insight moment said, *"that too was a little bit eye-opening, at least for me, because again, you know, wouldn't you want to know anyway? You know, even if it's good news or if there's no, you know, need for an*

intervention" (C8-I1). Recognising this insight, the team wanted to ensure any data presented was of value to make clinical decisions, not data for data's sake.

Next steps. The team were preparing to present to the enterprise-level joint steering committee at the end of June 2022. This represents Cadence Gate A, and gaining approval to move to Phase B (Cx-D1) is a significant milestone. Secondly, they were requesting to begin a preclinical infection model to prove the device can detect infection, and if this were successful, they would move on to observational human study. Finally, the Marketing Director (C8-I4) was intending to conduct further market research to understand the surgical applications and pricing.

9.4.2.2.2 May to October 2022

Project Strategy. Pricing for the device had been the subject of an ongoing internal discussion. The Marketing Director (C8-I3) found that if they sold the device at a higher price than a standard wound care dressing, they had to show improved clinical outcomes. The business case looked favourable once this assumption was built in. The Principal Engineer (C8-I2) spoke about the ongoing issues with project budgets; the business unit was trying to adopt a venture capitalist model for budgeting and prioritising innovation projects using a milestone approach. However, the bureaucratic structure and yearly budgeting cycles of a large corporation caused delays for the team. He spoke about how projects ran faster with the old model, "*I think the approach of being so conservative and worried that money is going to be thrown away"* (C8-I2).

Engaging with Customers. By the second interviews, the team had conducted two preclinical studies and generated favourable data (C8-I1). They had also concluded two formal rounds of VOC with 35 surgeons (C8-I3); the questions were open-ended (C8-D1). Furthermore, an external agency conducted anonymised interviews with 15 surgeons, and each interview lasted about 60 minutes from February to April 2022 (C8-D2). This included chiefs of surgery and those in the hospital who make the decisions based upon the value analysis, such as procurement. One goal for the interviews was the validation of the clinical value proposition and the financial assumptions. The questionnaire covered aspects such as the healthcare context, what kind of decisions customers make for infection control, what kind of decision-making power they have, and what type of institution they work for (C8-D3).

Next steps. The next major milestone they were working towards was a clinical study planned to start in mid-2023. This would first determine if the preclinical studies translated into favourable results in humans under real-world conditions (C8-I1). They were also planning to extend the VOC into other markets outside the US - they wanted to obtain the local VOC: 15 surgeons in Australia, five to seven in Japan and the sales and marketing representatives. The Marketing Director (C8-I3) stated, "*It's more of a global approach when we develop a product because what we've had in the past is a lot of very U.S.-centric development"*.

9.4.2.2.3 October 2022 to January 2023

Since the 2nd interviews, the team has analysed the market research data they have gathered from the VOC activities. They had not found any new insights, and the VOC had confirmed their assumptions and development pathway. Consequently, they had passed Gate B and were moving to Gate C (Charter). Before they could pass Gate C and move into the NPD phases, they needed to receive favourable clinical data on the product (CX-D1). They were also working on the TPP (C8-D1) for Gate C.

Iterative Design and Development. In 2023, they had gathered some *"killer questions"* (C8-I1) that they were working through. Killer questions were the issues they had encountered that needed to be resolved, or else the development would not be able to continue. The main killer question was regarding information security, "*once you collect this human data, where does it live, how does it get transmitted and communicated, aggregated?"* (C8-I1). At the time of the interview, the team were still working through this. This was also connected to the design issue of moving personal care from a hospital to a home environment.

Project Strategy As the product would be digitally connected, the 'go-to-market' and pricing strategy was being developed. They were also still competing across the organisation for the project budget and had to continue to show value.

The development focused on the customer side to understand the patient experience and design the patient reader and software application. From a technology and clinical side, the closure methods the device would work with (suture, staples, adhesives) were required to be specified. It was foreseen that these customer engagement activities in the coming year will produce customer needs and insights.

Planned clinical study. Whilst the design was progressing, the team was, in parallel, preparing a prototype for the clinical study to understand if the product could detect infection and provide a clinical benefit.

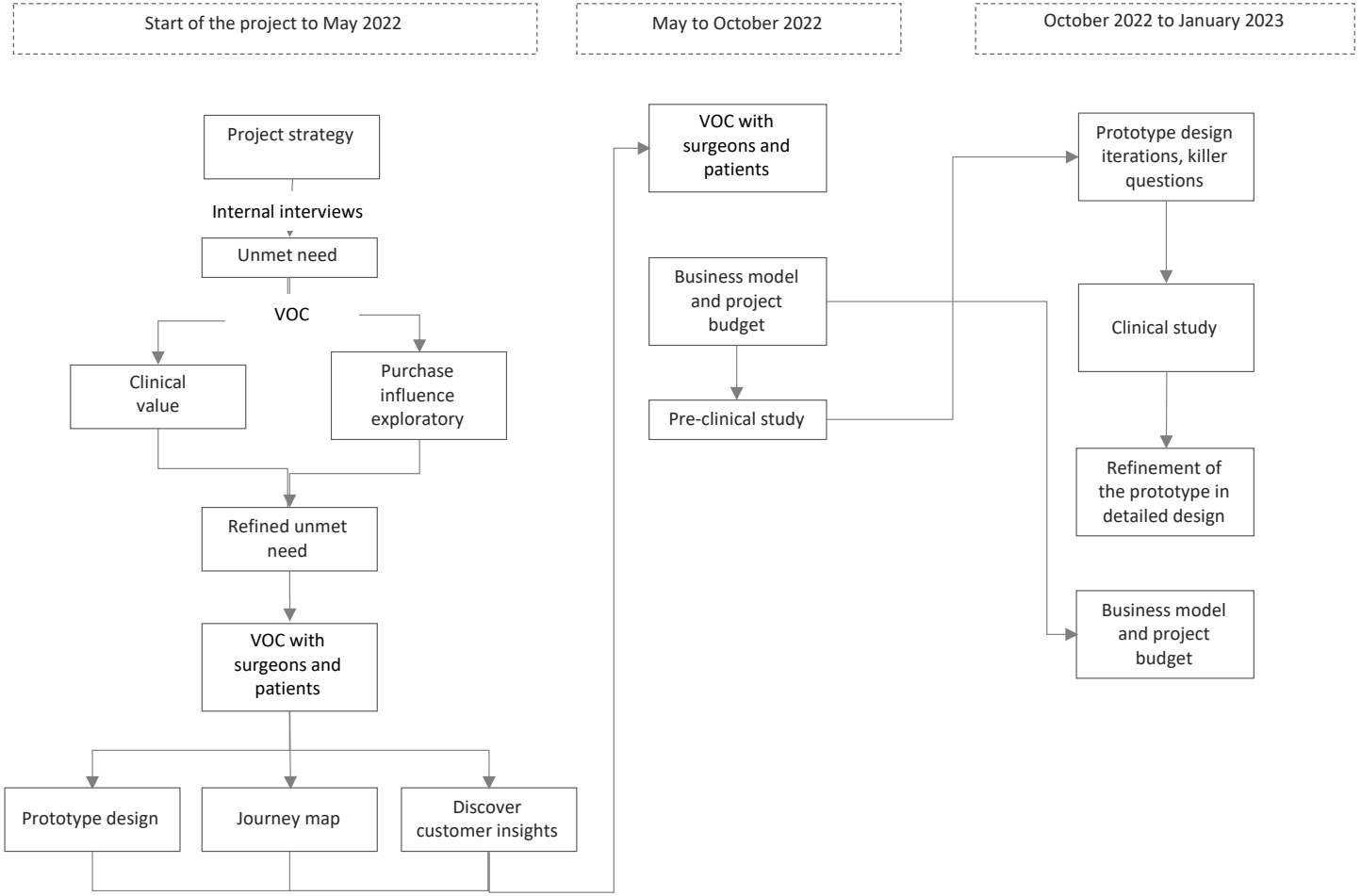
9.4.2.3 Summary of the Violet Project

In summary, over the nine months that this project was followed, the team pursued four main activities: 1) engaging with customers in multiple market research studies to understand the unmet clinical needs, customer needs and customer insights, 2) technology landscape review to define which sensor technology to use and the development of the sensor with the wound care devices, 3) a preclinical study, and 4) refinement of the project strategy and business model. The work led the team to complete Cadence Gate A and move into Cadence Gate B (Cx-D1). After the three interviews over the nine months, the Violet project still needed to complete the FEI stage. This would have been done after the clinical study in 2023.

Three customer insights were found when the team engaged with the customers and tested the prototype. Firstly, they discovered that discussing infection control with clinicians is a sensitive subject, which may lead to biased answers from customers. Consequently, they changed their approach to the VOC. Secondly, the team discovered when the customers used the prototype that the data aspect produced two main concerns: the security aspect and how the data impacts clinical decision-making. Finally, connected to the second insight were the legal implications for the clinicians and their decision-making. The team were continuing to explore the clinical decision-making and data security concerns and had yet to find a viable solution.

The discovery of the customer insight process described above was revealed through the coding of the elements and practices the team undertook in the front end. Appendix J.3 provides the practices and elements and the associated participant quotes and references to the documents. Figure 9-8 illustrates the process the team went through. The period for each of the activities is shown in the dotted line boxes, the inputs and outputs are in the solid line boxes, and the practices are shown by overlaying the arrows. Refer to Appendix J.2 and the first- and second-order data structure.

Figure 9-8: Framework for the Insight Process for Violet



Source: Author; based on Appendix J.3

9.5 OVERVIEW OF THE PLANETARY CASE STUDY 9

Planetary is a product innovation within the shoulder reconstruction business unit. The marketing and R&D functions are in the USA. Planetary is the development of a robotic shoulder reconstruction system. As this is a longitudinal study, data was captured at three points during the front end. At the time of the 3rd interviews, the project was still progressing through the later stages of the FEI.

10. The 1st interviews were in May 2022.
11. The 2nd interviews were in September and October 2022.
12. The 3rd and final interviews were in January 2023

9.5.1 Data Collection for Planetary

The data sources consisted of interviews and company documents.

9.5.1.1 Interviews

The semi-structured interviews involved marketing and R&D functions. For details of the participant's role and responsibility, interview duration, and date, refer to Table 9-7. The total time for all the interviews was 4 hours 12 minutes.

Table 9-7: Interview Details for Planetary

Interview Number	Role, Job Title	Case Reference	Experience in NPD	Interview	Date	Interview Duration (min.sec)
1	R&D Manager	C9-I1	3 years in the company PhD	1	April 2022	35.51
				2	October 2022	25.16
				3	January 2022	20.46
2	R&D Director	C9-I2	5 years in the company 20 years' total experience	1	April 2022	30.26
				2	September 2022	19.05

				3	January 2023	23.19
3	Lead Engineer	C9-I3	8 years in the company PhD	1	April 2022	26.36
				2	September 2022	18.24
				3	January 2023	26.18
4	Engineer	C9-I4	7 years in the company	1	April 2022	30.08
				2	Unable to be interviewed	
				3	Unable to be interviewed	
					Total	304 minutes

Source: Author

9.5.1.2 Documents Details for Planetary

Three project documents were collected from the interviews. Table 9-8 lists the documents.

Table 9-8: Document Details for Planetary

Document Number	Title	Document Content	Number of Pages	Date	Author
C9-D1	Target Product Profile (TPP)	Contains the unmet need and strategic direction	16	December 2022	R&D Director
C9-D2	Front end feasibility process	Describes the front end process	33 slides	January 2023	Lead Engineer
Cx-D1	Cadence stage-gate guidance v11	Instruction on the Cadence stage-gate process & overview slide	25	October 2021	Business Unit

Source: Author

9.5.2 The Insight Discovery Process

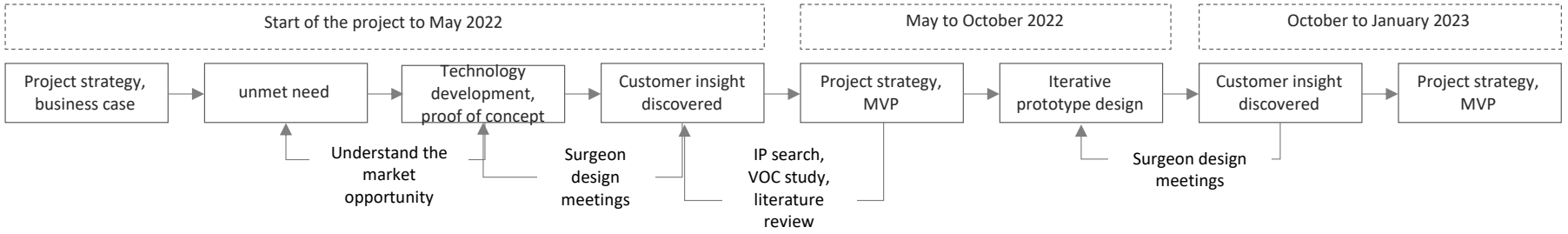
9.5.2.1 Coding and Process Framework

The interviews covered the participant's experience through the FEI with this specific project; the interviews explored the crucial process steps, activities, and outputs in the process. The coding generated:

- 24 first-order for the first interview; these were then aggregated into five second-order codes.
- 18 first-order for the second interview; these were then aggregated into three second-order codes.
- 13 first-order for the third interview; these were then aggregated into three second-order codes.

The aggregated second-order codes revealed that the team pursued five process steps through the FEI: project strategy, understanding the unmet need, engaging with customers, discovering customer insights, and iterative design and development. Furthermore, the coding of the interviews also revealed the inputs, actions, and outputs. To demonstrate the validity of the coding, Appendix K.3 provides the coding structure with representative quotes, and Appendix K.2 shows the data structure. Figure 9-9 illustrates the process for the project. Finally, following the overview, a narrative describes the process with associated quotes to provide a richer understanding of the case study.

Figure 9-9: Overview of the Insight Discovery Process for Planetary



Source: Author; based on Appendix K.3

9.5.2.2 Narrative for Insight Discovery Process Framework for Planetary

9.5.2.2.1 Start of the project to May 2022

Project Strategy. The project commenced due to an acceptance by the business unit that they were late to the digital shoulder application (computer-assisted navigation) market (C9-D1). The value proposition (C9-D1, p. 8) was "*to disrupt the market and maintain leadership, investment in the portfolio and digital to transform healthcare in shoulder arthroplasty by unlocking bone and tissue sparing techniques. Accuracy is the core unmet need and expectation of digital technologies in the shoulder. Differentiation will be achieved through a superior user experience by empowering surgeons with agency via a simple, efficient, and cost-effective solution. The proposed project is a multigenerational solution to grow a bone-sparing and tissue-sparing procedural solution with enabling technologies of planning, portable navigation, and geofencing*". The project was initially tasked to use the Velys orthopaedic robotic solution. However, in communicating the added value the application could bring for low-volume shoulder surgeries the robot was a high capital expense for a hospital, which presented a challenging business case, *"one of the main ones is recently we were trying to develop this application to use on the Velys robot so that there's an existing robot that we that's in the field right now being used for total knee surgery, and we were hoping to be able to use that for a total shoulder application as well"* (C9-I2). However, through initial cadaver labs, the team found that the robot was not well suited for shoulder surgery. The R&D Director (C9-I2) stated, *"but due to the limitations of the robot and where it needs to be placed and where it can reach as we evaluated it and cadaver labs with our customers, with surgeons, we realised there's not a good place to put the robot".* The R&D Manager (C9-I1) explained there was a tension between the technology and the business case; they needed to build a *"proof-of-concept"* to prove the business case and technology. Therefore, the shoulder project evolved as the team learned what was possible from the technology, clinical environment, and business perspective. One pathway that was considered was Augmented Reality (AR) glasses instead of the robot, which provided the benefit of lower cost and did not obstruct the surgery as the robot had. As such, the team were moving towards AR and proving the concept, *"we're defending the project right now. The further you get into the cadence, the more investment you need to make. And so, there's really a*

push now to make this just purely feasibility and avoid all the documentation and figure out if it can work" (C9-I2).

Understanding the Unmet Need. In parallel to defining the project strategy, the team used basic prototypes to understand the unmet need and focused on the *"clinically meaningful"* (C9-I3) aspects instead of the solution. For example, they identified early that the glenoid position would add the most value for computer-assisted navigation. This value was extended to include both reverse shoulder implants and alignment variability of short stems (C9-D1).

Technology Development. The team started the concept design work early. Using the existing Velys robot and studying competitor systems, they developed a proof of concept within one year (2021) to demonstrate and gain quick feedback. Using the prototype, they encountered technical challenges with the Velys robot. In the surgical environment, the robot camera could not 'see' all the arrays, as the surgeons stood in front of the surgical site, and the size and footprint of the robot also obstructed the surgeons. Due to cost and time constraints, they could not redesign the robot for shoulder surgery to address these issues. Based on their insights, the team looked at alternative solutions, a hand-held robot and AR glasses. AR glasses showed the most value in addressing the unmet need and avoiding the technical challenges of the robot. The R&D Director (C9-I2) stated, *"we're looking to use some existing commercially available headsets to prove the workflow and develop some instruments so we can actually be able to show some of our customers".* The Velys robot prototype, though not used, still helped them validate the unmet need and surgical workflow.

Engaging with Customers. The team undertook a large VOC study involving both high-volume and low-volume shoulder surgeons, *"something in the order of 90 or 75 per cent of surgeons who do total shoulders do less than 20 a year"* (C9-I3). They explored the workflows, the device's value, and the critical navigation steps. The Lead Engineer (C9-I3) explained the problems he experienced with the VOC study:

> *"So, this is an interesting one because most people have no experience with shoulders and navigation. So, it's funny because we talk about if we have AR in robotics and how they come together in the future. It's a funny question because we have neither today. So, how can we expect anyone to tell us what they look*

like together later? So, a lot of our questions come down to market research questions like, is this a problem for you? Do you have a need? If we had a solution that could do this, what are the most important characteristics of it? How sensitive are you to time if it reduces your error? So, they're more abstract, less specific technical questions and more about market adoption. And what are the barriers to adoption in their practice, their hospitals, and high-level characteristics of a solution that they might like to see?"

Discovering Customer Insights. Customer insights were discovered about the customers in these early stages. The Lead Engineer explained his realisation, *"one of the things that I found surprising and therefore insightful was that whether you're a low-volume or high-volume surgeon, there's a lack of confidence in what they're doing today. It also helps create the need for navigation. So that comes first. We already knew there was a problem with accuracy and that open placement, for example, where we know there's a need. This provides that further insight into the nuances of that need is not just limited to low volume surgeons but even experts want to have further confidence in what they're doing is right*" (C9-I3). Another learning from engaging the customers was that the technology platform was unimportant. The robotic solution was an internal driver. The surgeons said they struggled with visualising the structure and alignment of the shoulder implant and needed a solution to help them (C9-I4). This new knowledge helped the team move away from a robot solution and its associated issues toward an AR solution.

Next steps. In the next step, the team planned to refine the designs of the instruments and find an AR glasses partner to develop the application. They hoped to create an AR proof of concept by mid-2022 and test it with customers to understand the problems further.

9.5.2.2.2 May to October 2022

Engaging with Customers. The team engaged the surgeons to test the prototypes at a VOC summit in Madrid. At the meeting, they verified the AR concept approach and utility. The Lead Engineer stated (C9-I3) that when the VR headset was put on the surgeon's head, *"their mind is really blown like they're surprised and shocked at how intuitive and user-friendly it is"*. They also explored what information should be displayed and then created a storyboard for the screen layouts throughout the surgery. The experience of using AR

gave the team a new perspective on shoulder surgery. They could never experience the surgery in the first person, but seeing through the surgeons' eyes provided a deeper understanding.

Iterative Design and Development. The team progressed and used commercially available AR glasses to gather feedback and iterate the design. They incorporated the tissue-sparing approach into the application and surgical instruments, *"it's really been an early concept refinement for the tissue-sparing, but for the robotic AR discussion, it's been sort of rapid iteration and exploration of new technology"* (C9-I3). They spent most of the time experimenting with what information to display on the glasses. The Lead Engineer (C9-I3) explained, *"I think that's what we're calling the secret sauce; it's like just showing them as little information as possible, but at the right time, don't flood them with room temperature, blood pressure. All the things you could give them all at once probably isn't necessary".*

Project Strategy. At the time of the second interview, a review of the digital shoulder program had been conducted. The robotic solution was put on hold, and the team focused on the AR solution. The cost of the robot was seen as too prohibitive for the customers to purchase, and the complications of the robot in shoulder surgery could not be overcome. The R&D Director (C9-I2) reiterated that the unmet need had not changed, and the TPP was still valid (C9-D1). The team also incorporated the ability to do pre-op planning in the application and a tissue-sparing approach to add more value. An AR technology partner search had not yet been concluded, which was causing delays, "*that's been the theme of this year is the absence of being able to move forward with the partner, what can we do? Like what can add value right now so that we do sign a deal with a partner*" (C9-I2).

Next steps. Another lab with the surgeon team was scheduled in December 2022, and the team continued to build the software workflow.

9.5.2.2.3 October to January 2023

Project Strategy. The team were challenged by senior management at the end of 2022 to define the MVP. The R&D Manager (C9-I1) described the situation, *"we are really trying to understand what truly the MVP is, to be able to go fast because, of course, our leaders would like us to go faster*". They were asked to have a product available on the market in

2024. However, the interoperative surgical solution could not be launched until 2025. So, they had to reduce the scope further and only focus on the glenoid side of shoulder surgery, eliminating the humeral side (C9-D1). Also, other functionality was removed from the prototype to achieve an MVP for 2024.

Engaging with Customers. The lab was the first time the surgeon team had seen a fully functioning prototype, "*so this time, we're able to have some interesting discussions with them to try to understand what they would like at a minimum so that that's part of the process"* (C9-I1). At the lab, there were discussions on the nice-to-have functions and must-haves to define the MVP further.

Iterative Design and Development. The design concept was finalised at the end of 2022, with a few minor improvements still to be addressed. They had also conducted a lab in November but had yet to analyse the data and comments. Still, they saw some additional development work based on the feedback, especially around the information display and the 3D projections on the AR glasses.

Discovering Customer Insights. One customer insight discovered at the lab was the difference between young and old surgeons. Young surgeons preferred the 3D views, but more senior surgeons preferred the 2D. The teams' interpretation was that younger surgeons are more used to playing computer games with 3D projections. Older surgeons are more accustomed to using X-rays, which are 2D representations of a 3D object. The R&D Manager (C9-I1) stated, "*though they're looking at two dimensions, the older surgeons, their brain is putting it together into 3D in the mind's eye*".

Next steps. The team was planning to charter in late 2023 (C9-D4). The remainder of 2023 was the iteration of the design concept, selecting a commercial headset, improving accuracy, and refining the tissue-sparing approach.

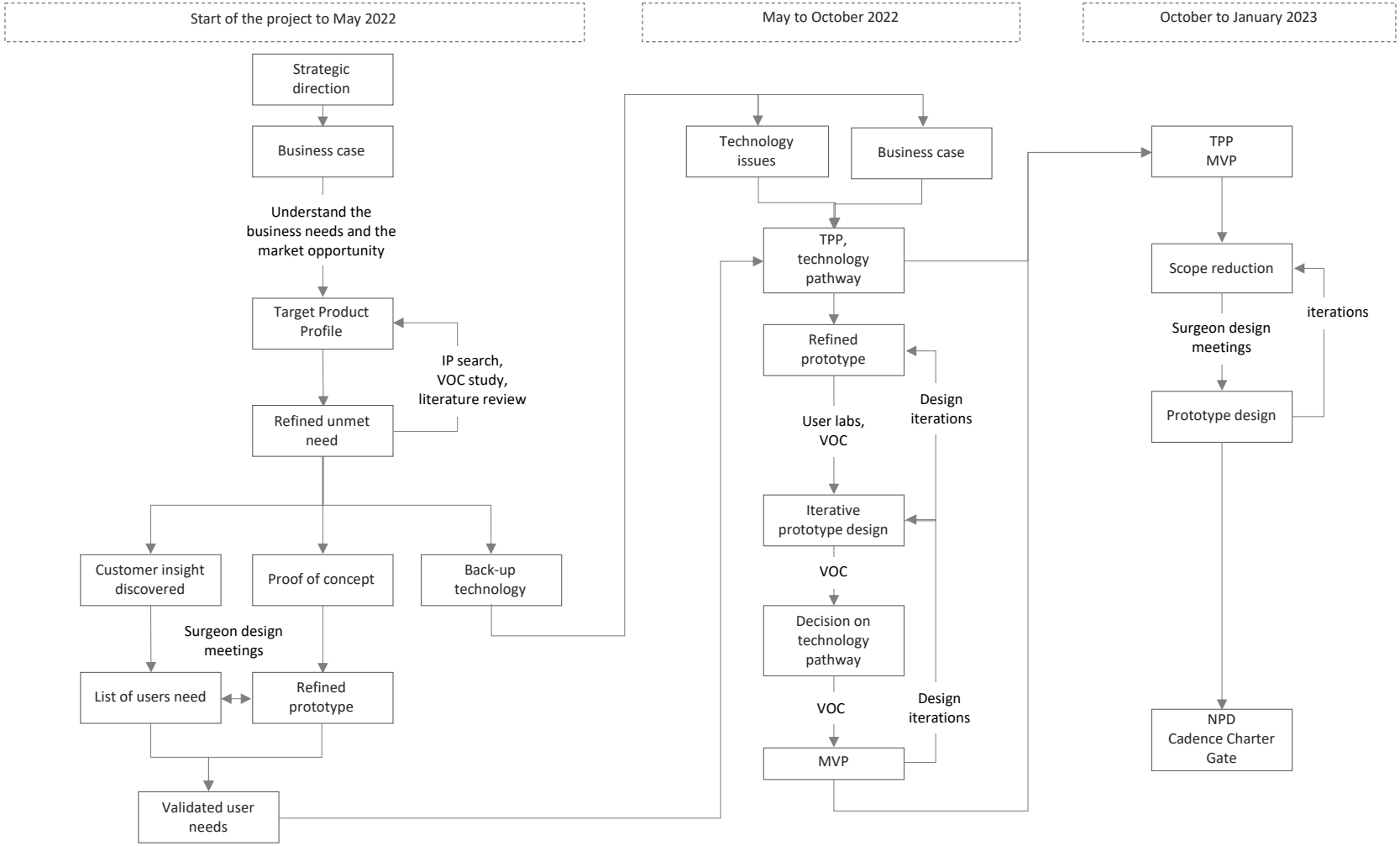
9.5.2.3 Summary of the Planetary Project

In summary, over the nine months that this project was followed, the team pursued three main activities: 1) understanding the project strategy, business case and technology solution, 2) iterating the design concept, and 3) engaging with customers to refine the robotic and then the AR design concepts. The process described is shown in Figure 9-10. Three customer insights were found when the team engaged with the customer and used

the prototype with the surgeons. Firstly, they discovered that surgeons wanted more confidence when performing shoulder surgery, and the design solution could provide this confidence. Secondly, the team discovered that the technology platform was not the critical driver for the customer's decisions, so they widened the technology solutions that could be utilised. Finally, there was a difference in practice between young and older surgeons; there has been no action taken based on this insight. After the three interviews over the nine months, the Planetary project had not yet completed the FEI. This would have been done after the final design concept was completed.

The discovery of the customer insight process described above was revealed through the coding of the elements and practices the team undertook in the front end. Appendix K.3 provides the practices and elements for the insight moment process shown below and the associated participant quote and reference to the documents. Figure 9-10 illustrates the process the team went through for the case study. The time for each of the activities is shown in the dotted line boxes, the inputs and outputs are in the solid line boxes, and the practices are shown by overlaying the arrows. Refer to Appendix K.2 and the first- and second-order data structure.

Figure 9-10: Framework for the Insight Process for Planetary



Source: Author; based on Appendix K.3

9.6 SUMMARY

This chapter presented the findings that addressed RQ 2: *How does the process of discovering customer insights unfold within innovation teams?* The analysis was based on interviews and documents and showed the insight discovery process that the teams followed for the longitudinal case study innovation projects. The four longitudinal case studies in this chapter cover four different innovation projects: a lung cancer treatment, a knee sagittal saw, a wound care device, and a total shoulder digital application.

The second-order coding for the four case studies in this chapter was informed by the second-order coding from the first case study reported in Chapter 6 and the retrospective case studies reported in Chapter 8. This was an iterative research approach and involved comparing different levels of data, analysing, and building a theory as the codes and concepts developed. The process was used as it begins with specific empirical data and builds towards a generalisable theory (Symon and Cassell, 2012). This process has been used with the longitudinal case study report (Chapter 9) and has assisted with the cross-case analysis. Three case studies presented in this chapter discovered insights in summary they were:

- Plexus (lung cancer treatment) discovered that there was a lot of flexibility in treatment and patient referral, and there were no clear clinical practices or country-specific standards. They found hospitals had suggested guidelines but needed to have defined practices. This insight came from the observations and interviews with the customers that were identified in the procedure map and the risk assessment.
- Stanley (knee sagittal saw), no insights were discovered during the study.
- Violet (wound care device) discovered that discussing infection control with clinicians is a sensitive subject, which may lead to biased answers from customers. Secondly, the team discovered that the data aspect had two main concerns: the security aspect and how the data impacts clinical decision-making. And finally, connected to the second insight were the legal implications for the clinicians in their decision-making.

- Planetary (total shoulder digital application) found that surgeons had a degree of confidence in shoulder surgery and wanted more control. Secondly, the team discovered that the customer was agnostic to the technology platform, but this was not an essential driver for their decisions. And finally, there was a difference in practice between young and older surgeons.

The longitudinal nature of these case studies was demonstrated by how the FEI process developed over time. The findings will be discussed further in the cross-case analysis in Chapter 10, together with the retrospective case study findings from Chapter 8.

CHAPTER 10 CROSS-CASE ANALYSIS FOR RQ 2

10.1 INTRODUCTION

Chapter 10 presents the findings of the cross-case analysis based on the nine case studies for RQ 2: *How does the process of discovering customer insights unfold within innovation teams?* The within-case analysis was presented in Chapters 6 and 8 for the five retrospectives and Chapter 9 for the four longitudinal case studies. The cross-case analysis aims to identify the similarities and differences across the cases (Yin, 2018). Chapter 10 is organised as follows:

- Comparison of customer insight and design insight
- Insight discovery process and FEI
- Comparison with collective sensemaking
- Summary of cross-case analysis chapter

10.2 COMPARISON OF RETROSPECTIVE AND LONGITUDINAL CASE STUDIES

There is a legitimate concern regarding the use of a combined retrospective and longitudinal approach to data collection and analysis, as the comparability of findings may be compromised across all cases. However, the advantages of this approach far outweigh its weaknesses.

Firstly, the dual retrospective and longitudinal methods focused on the same phenomenon, namely the process of discovering customer insights in the FEI. As a result, the cases were similar, and the collected data was similarly comprehensive. While a fully retrospective study would have been possible if longitudinal data were collected only at the time of the third interview, the longitudinal approach allowed for data collection closer to the process activities, thereby limiting recollection bias. This is similar to Leonard-Barton (1990, p. 254) description that “the data was obtained through retrospective reports gathered shortly after the events occurred”. Additionally, participants were able to provide prospective plans for their following activities.

Secondly, retrospective case coding occurred before longitudinal case coding. This method enhanced the analysis by tuning the research into the coding process and enabling the researcher to identify similarities and differences across the cases. For instance, findings revealed that insights could be considered customer and design insight depending on the FEI phase. This may not have been revealed with retrospective cases alone. By combining these methods, a broader perspective was gained, starting with the retrospective and further exploring the topic through longitudinal cases (Leonard-Barton, 1990).

Finally, the use of periods (with a three-month gap between each interview) provided a more detailed view of the timeline of events, allowing for a more robust analysis of relationships. This approach illuminated how specific factors or decisions impacted the case, ultimately leading to the development of a more nuanced framework.

Despite the unusualness of combining retrospective and longitudinal research designs, this approach has provided a deeper understanding of the process of discovering customer insights in the FEI. This broader perspective, combined with a multi-faceted data analysis, has led to a deeper comprehension of the underlying dynamics and contributed to advancing knowledge in the field.

10.3 INSIGHT DISCOVERY PROCESS AND FEI

The nine case studies followed distinct paths through their FEI process, though they were comparable in certain aspects. This can be seen from the insight discovery processes for each of the case studies, as illustrated in Figure 10-3: FEI Process Element Flow.

The cross-case analysis of nine case studies was compared to two existing FEI processes, the New Concept Development (NCD) model (Koen *et al.*, 2001, p. 47) and the New Product Development Front End (NPDFE) model (Khurana and Rosenthal, 1997, p. 105). Refer to Figure 10-1 for the NCD model and Figure 10-2 for the NPDFE model.

In the Koen *et al.* (2001) NCD model, the authors defined five FEI elements that have the circular, iterative flow between the elements: 1) opportunity identification, 2) opportunity analysis, 3) idea genesis, 4) idea selection, and 5) concept and technology development. The five elements can be combined or employed multiple times throughout the front end. The NCD model was based on questionnaires from 23 managers.

In the Khurana and Rosenthal (1997) NPDFE model, seven elements were defined, consisting of three foundational and four project-specific elements. The foundational elements were 1) project strategy, 2) product portfolio planning, and 3) product development organisational structure. The project-specific elements were 4) product concept, 5) product definition, 6) value chain considerations, and 7) front end project definition and planning. The model was based on case studies of 11 companies in Japan, the USA and Europe.

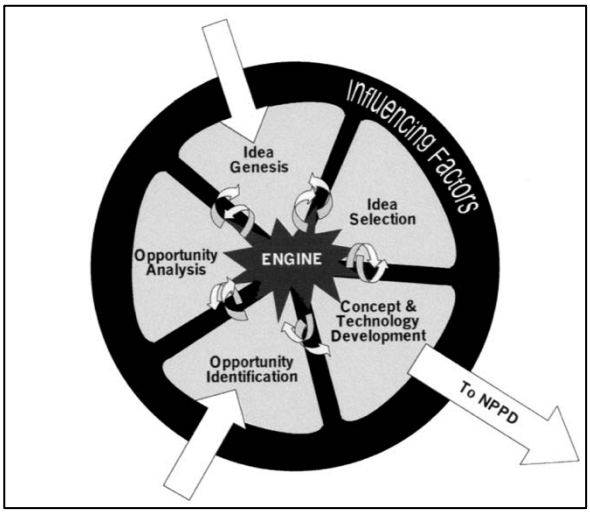
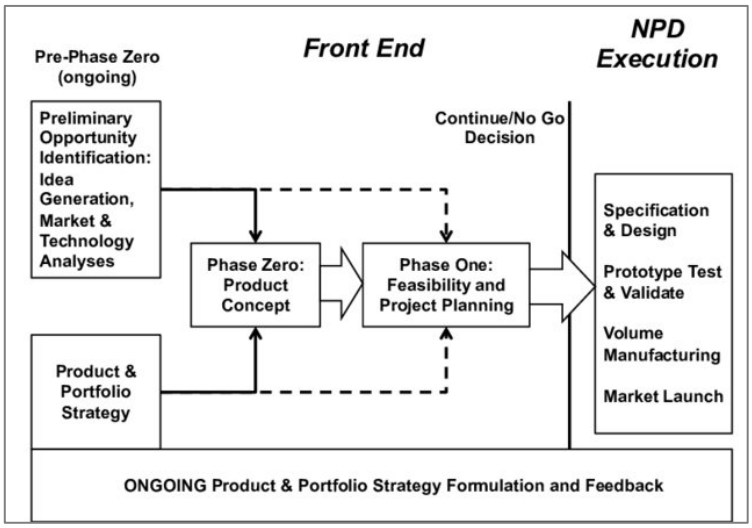


Figure 10-1: New Concept Development Model (NCD)

Source: Adapted from Koen *et al*. (2001)

Figure 10-2: New Product Development Front End Model (NPDFE)



Source: Adapted from Khurana and Rosenthal, 1997

Table 10-1 provides a list of the elements and a brief description of the NCD and NPPD models. Table 10-2 then contrasts the elements to understand how the two models' elements fit each other to highlight any similarities and differences. This analysis was then used to fit the elements into the cross-case project elements.

Table 10-1: FEI Model Elements and Description

FEI Elements	Description
New Product Development Front End model (NPDFE). Khurana and Rosenthal (1997)	
Foundational Elements	
1. Product and Portfolio Strategy	Strategic vision, a product platform strategy, and a product-line strategy to support the go/no-go decision for a new product. technology planning.
2. Product Portfolio Planning	Maps initiatives across the business to balance risk and potential return.
3. Product Development Organisational Structure	Decisions on structure, communication networks, and roles.
Project-Specific Elements	
4. Product Concept	Preliminary identification of customer needs, market segment, competition, business prospects and alignment with existing business and technology plans.
5. Product Definition	Elaboration of the product concept. Identification of customer needs, technologies, and regulatory requirements. Leading to product features, market, and design priorities.
6. Value Chain considerations in product definition	Upstream and downstream issues.
7. Front end project definition and planning	Project priorities, task, schedule, resources, risks.
New Concept Development (NCD) model. Koen *et al*. (2001)	
1. Opportunity Identification	Business and technology opportunities are considered, resources allocated.
2. Opportunity Analysis	Additional information from the opportunity identification. Extensive market research.
3. Idea Genesis	Birth and development of the opportunity into concrete ideas.
4. Idea Selection	Choice of ideas to pursue, to achieve the most business value.
5. Concept and technology Development	Development of the business case.

Source: Author

Table 10-2: Comparison of FEI Model Elements

No ID	New Product Development Front End model Khurana and Rosenthal (1997)	New Concept Development model Koen et al. (2001)	Comment on Differences and Similarities	Case Study Project Elements
1	Product and Portfolio Strategy	Opportunity Identification	A similar process for both models, though the split is different.	Project Strategy
2	Product Portfolio Planning	Concept and Technology Development	Same process for both models.	Project Strategy
3	Product Development Organisational Structure	No Comparison	No equivalent for the NCD model, it does not cover organisation structure.	Project Strategy
4	Product Concept	Opportunity Identification Idea Genesis Opportunity Analysis	A similar process for both models, though the split is different.	Technology Development Understanding the Unmet Need Iterative Design and Development Understanding the Customer Needs Discovering Customer Insights
5	Product Definition	Opportunity Analysis Idea Selection	A similar process for both models, though the split is different.	Engaging with Customers Iterative Design and Development Understanding the Customer Needs Discovering Customer Insights
6	Value Chain considerations in product definition	Opportunity Identification	Same process for both models.	Project Strategy
7	Front end project definition and planning	No Comparison	No equivalent for the NCD model, it does not cover project management.	Project Strategy

Source: Author

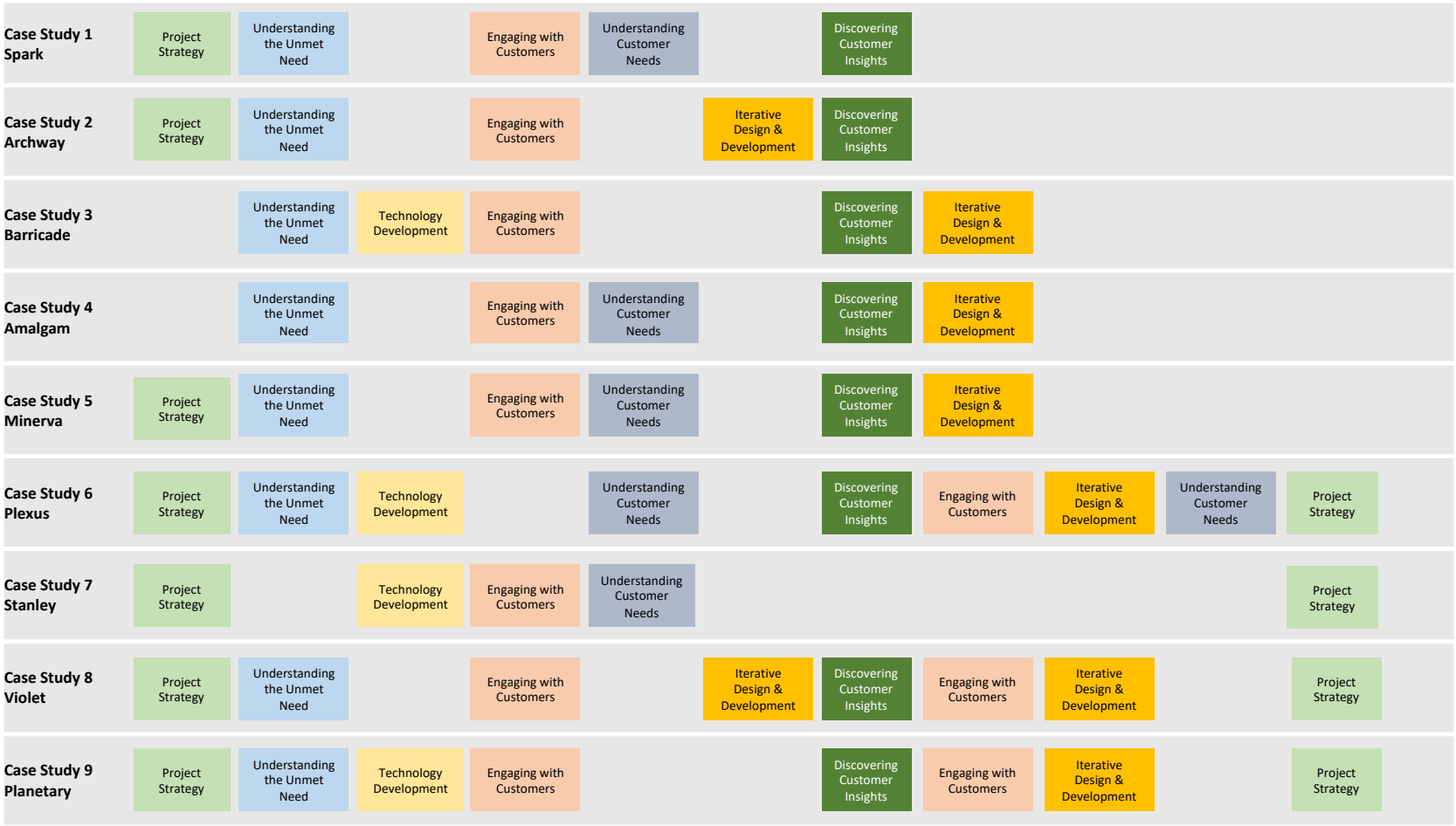
Comparing the FEI process across the nine projects, the process flow has been graphically laid out horizontally (see Figure 10-3). Taking Koen's (2001, p 48) lead, these seven have been defined as elements instead of process steps or phases, as a 'process implies a structure that may not be applicable and could force a set of poorly designed NPD controls to be used to manage FEI activities'.

Each of the seven elements has been colour-coded to provide a visual overview. Though the elements in the figure are laid out horizontally and linearly, in reality, it is much fuzzier; elements can overlap, be concurrent or sequential. As such, the elements are iterative. A linear flow was chosen as it affords a clearer comparison between the different projects than a circular flow would.

That said, project strategy was the first element for all the projects, followed by understanding the unmet need. This is similar to how Koen *et al.* (2001) proposed the circular flow in the FEI; the author also proposed that the FEI begins with the opportunity identification, which then leads to the other elements (Figure 10-1). This iterative cycle can be seen in the longitudinal innovation projects (case studies 6, 7, 8, and 9). Three elements were refined as the innovation teams gained new information, such as engaging with customers, iterative design and development, and project strategy. As illustrated by the frameworks for each of the case study projects (Chapters 8 and 9), each team pursued different activities throughout the process.

Addressing the reported fuzziness of the front end, since both Khurana (1997) and Koen's (2001) papers were published, a significant amount of research has been conducted on the front end. In particular, front end theories, for instance, Design Thinking (Liedtka, 2014), Stage-Gate (Cooper, 2016), Biodesign (Yock, Zenios and Brinton, 2015), MVP (Ries, 2011), along with many others. These papers have assisted in reducing the fuzziness and providing more clarity. In the MedDevCo organisation, the teams all used the company's Cadence stage-gate process (Appendix C.2), which clearly defined the outputs. Additionally, the teams executed the front end with the intention of discovering insights and having an awareness of what they were looking for. As the teams progressed through the front end, their path became more apparent, especially when the insights were discovered. Therefore, the fuzziness of the front end was not so pronounced in the case studies.

Figure 10-3: FEI Process Element Flow



Source: Author

Table 10-3: Cross-Case Comparison of FEI Elements

NPDFE Model Elements	NCD Model Elements	1 Spark	2 Archway	3 Barricade	4 Amalgam	5 Minerva	6 Plexus	7 Stanley	8 Violet	9 Planetary
Product and Portfolio Strategy Value Chain Front end project definition and planning Product Development Organisational Structure	Opportunity Identification	Project Strategy	Project Strategy	Project Strategy	Project Strategy	Project Strategy	Project Strategy	Project Strategy	Project Strategy	Project Strategy
Product Concept	Opportunity Identification	Understanding the Unmet Need	Understanding the Unmet Need	Understanding the Unmet Need	Understanding the Unmet Need	Understanding the Unmet Need	Understanding the Unmet Need	Understanding the Unmet Need	Understanding the Unmet Need	Understanding the Unmet Need
Product Concept	Opportunity Identification			Technology Development			Technology Development	Technology Development		Technology Development
Product Concept	Opportunity Analyses	Engaging with Customers	Engaging with Customers	Engaging with Customers	Engaging with Customers	Engaging with Customers		Engaging with Customers	Engaging with Customers	Engaging with Customers
Product Concept	Idea Genesis	Understanding the Customer Needs			Understanding the Customer Needs	Understanding the Customer Needs	Understanding the Customer Needs	Understanding the Customer Needs		
Product Concept	Idea Genesis							Iterative Design and Development	Iterative Design and Development	
Product Concept	Idea Genesis	Discovering Customer Insights	Discovering Customer Insights	Discovering Customer Insights	Discovering Customer Insights	Discovering Customer Insights	Discovering Customer Insights		Discovering Customer Insights	Discovering Customer Insights
Product Definition	Opportunity Analyses						Engaging with Customers	Engaging with Customers	Engaging with Customers	Engaging with Customers

NPDFE Model Elements	NCD Model Elements	1 Spark	2 Archway	3 Barricade	4 Amalgam	5 Minerva	6 Plexus	7 Stanley	8 Violet	9 Planetary
Product Concept	Idea Genesis	Iterative Design and Development	Iterative Design and Development	Iterative Design and Development	Iterative Design and Development	Iterative Design and Development	Iterative Design and Development		Iterative Design and Development	Iterative Design and Development
Product Concept	Idea Genesis						Understanding the Customer Needs			
Product, Portfolio Planning	Concept and Technology Development						Project Strategy	Project Strategy	Project Strategy	Project Strategy
Product Definition	Idea Selection								Iterative Design and Development	Iterative Design and Development
Product Definition	Idea Selection						Discovering Customer Insights			
Product Definition	Idea Genesis						Understanding the Customer Needs			
Product Definition	Idea Selection									Engaging with Customers
Product and Portfolio Strategy	Concept and Technology Development						Project Strategy	Project Strategy	Project Strategy	Project Strategy

Source: Author

10.3.1 FEI Seven Elements

The seven elements are discussed below in detail.

10.3.1.1 Project Strategy

All nine innovation projects conducted a project strategy element at the beginning of the FEI process. This aligns with the Product and Portfolio Strategy (NPDFE) and Opportunity Identification (NCD) elements that also commence the FEI process. The longitudinal innovation projects revised and updated the project strategy through the front end, in particular, the business case and TPP outputs. For the NPDFE model, the business case is captured in the Concept and Technology Development element at the end of FEI. For instance, Barricade's (3) project strategy activities consisted of assembling the team and performing a technology landscape search to identify the appropriate technology for the identified business need. Table 10-4 provides a list of the inputs, practices, and outputs across the projects for the project strategy element, prioritised by the most frequent. For instance, the 'strategic direction' input was reported by seven projects.

Table 10-4: Project Strategy Inputs, Practices and Outputs

	Case									**Total**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Inputs										
Strategic direction (Multi-generational platform plan, competitor market disruption, unmet clinical need)			x	x	x	x	x	x	x	7
Business need and business case	x	x					x	x	x	5
Identified technology		x							x	2
Practices										
Understanding strategy, business, market, and budget				x		x	x		x	4
Internal design workshops (brainstorming)		x					x	x		3
Understanding the clinical and patient problems		x			x			x		3
Literature and IP search				x		x			x	3

Assembling the team		x	x							2
Technology landscape search			x		x					2
Informal discussion with customers	x			x						2
Outputs										
Unmet clinical need (clinical value)	x	x		x	x		x	x	x	7
Project strategy				x	x	x	x	x	x	6
Technology landscape review (risks, issues)			x		x					2
Team established		x	x							2

Source: Author

10.3.1.2 Understanding the Unmet Need

Understanding the unmet need was conducted after the initial project strategy was confirmed. The nine projects all conducted activities to investigate the unmet clinical need and refine their understanding of the business opportunity and technology. The project strategy and business case may have changed, but the unmet clinical need did not. Understanding the unmet need represents a crucial step. It represents the first development element in the FEI. For instance, Plexus (6) used the practice of ethnographic research to understand the unmet need, which produced the outputs - defined unmet clinical need, identified customer group, and a procedure map. Table 10-5 provides a list of the inputs, practices, and outputs across the projects for the understanding of the unmet need element, prioritised by the most frequent. As can be seen, the 'unmet clinical need' output was reported by eight projects.

Table 10-5: Understanding the Unmet Need Inputs, Practices and Outputs

	Case									**Total**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Inputs										
Unmet clinical need (clinical value)	x	x			x	x		x	x	6
Project strategy			x	x	x	x				4
Identified technology			x							1
Practices										
Market research (surgeon interview, surveys, user	x	x		x	x					4

feedback)										
Internal design workshops (brainstorming)			x				x			2
Ethnography (observation, interviews)		x				x				2
VOC								x	x	2
Outputs										
Unmet clinical need (clinical value)	x	x	x	x	x	x		x	x	8
Customers groups (patients, clinicians)	x				x	x		x		4
Procedure map, surgical workflow						x	x			2
Project strategy	x	x								2
Design concept prototype							x			1

Source: Author

10.3.1.3 Technology Development

Four projects (Barricade, Plexus, Stanley, Planetary) conducted a technology development component. Three of the four longitudinal cases reported a technology development component, and only one of the five was retrospective. Though only four cases of the nine reported on technology development, it was considered a crucial element of the projects. With the team working on the element, the project progressed. Therefore, this has been included as an element. It was also included as technology development falls within the product concept (NPDFE) and the opportunity identification (NCD) elements. Table 10-6 provides a list of the inputs, practices, and outputs for technology development, prioritised by the most frequent. As can be seen, Planetary (9) performed the most technology development activities of all the case studies. The team analysed the technology and associated risks and performed a competitor technology search; this produced a proof-of-concept output and a backup technology solution.

Table 10-6: Technology Development Inputs, Practices and Outputs

	Case									**Total**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Inputs										

Unmet clinical need (clinical value)		x		x	x	3
Technology landscape review (risks, issues)		x	x		x	3
Procedure map, surgical workflow			x		x	2
Practices						
Technology analyses and risks				x	x	2
Technology landscape search			x		x	2
External partnering		x				1
Outputs						
Proof of concept		x		x	x	3
Technology landscape review (risks, issues)		x	x		x	3

Source: Author

10.3.1.4 Engaging with Customers

The projects engaged with customers early to better understand the unmet need, performing preliminary interviews and market research. Though engaging customers occurs throughout the FEI, there were two main areas where the teams dedicated the most attention; these were gathering and analysing the customer needs and evaluating the prototype design concepts. All nine projects engaged the customers in the FEI. Table 10-7 provides a list of the inputs, practices, and outputs across the projects for the engaging with customers element, prioritised by the most frequent. As can be seen, Barricade (3) utilised most of these practices in its efforts to engage customers.

Table 10-7: Engaging with Customers Inputs, Practices and Outputs

	Case									**Total**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Inputs										
Unmet clinical need (clinical value)	x	x		x				x	x	5
Design concept prototype	x		x				x		x	4
List of questions		x	x							2
Customers group (patients, clinicians)					x					1

Practices										
Market research (surgeon interview, surveys, user feedback)	x	x	x	x	x		x		x	7
VOC		x	x		x			x	x	5
Simulated use of existing (preclinical, cadaver)			x	x	x			x	x	5
Surgeon co-design and evaluation of prototype	x			x	x		x			4
Internal design workshops (brainstorming)	x		x							2
Ethnography (observation, interviews)			x			x				2
Outputs										
Design concept prototype	x		x	x			x	x	x	6
Uncovered preliminary customer needs	x	x	x			x			x	5
Market research report (VOC)		x		x	x	x		x		5
Design ideas and storyboarding	x			x					x	3
Procedure map, surgical workflow			x			x			x	3
Technology landscape review (risks, issues)		x							x	2

Source: Author

10.3.1.5 Understanding the Customer Needs

A key output to this element was a list of identified customer needs that were validated and prioritised. All nine projects created a list and refined the list as they progressed. Table 10-8 provides a list of the inputs, practices, and outputs across the projects for the engaging with customers element, prioritised by most frequent.

Table 10-8: Understanding the Customer Needs Inputs, Practices and Outputs

	Case 1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**
Inputs										
Uncovered preliminary customer needs	x			x	x	x	x	x	x	7

List of validated and prioritised customer needs	x		x	x	x	x			x	6
User needs (VOC) report (feedback on prototype)				x	x		x			3
Procedure map, surgical workflow						x	x			2
Design risks and issues assessment				x		x				2
Practices										
Needs assessment refinement and weighting (JOC)	x			x	x	x				4
Internal design workshops (brainstorming)	x			x	x		x			4
Simulated use of prototypes (observation)	x			x	x					3
Consolidate, craft, validate needs statements				x		x				2
Interpreting market research data into needs				x	x					2
Outputs										
List of validated and prioritised customer needs	x	x	x	x	x	x	x	x	x	9
Design concept prototype				x	x		x			3
Identified MVP						x				1

Source: Author

10.3.1.6 Iterative Design and Development

All nine projects iterated the prototype design concept during the FEI; the prototype was the key artefact in the FEI process and was used to drive most of the discussion internally and externally. As the name of this element suggests, the prototype was changed and improved to address feedback and new information. As stated by Stigliani and Ravasi (2012, p. 1249), ideas, concepts, sketches and prototypes that are collectively referred to as material practices are "involved in the gradual organisation of individual experiences and the group-level integration of ill-defined early ideas into new and more refined shared mental structures". Table 10-9 provides a list of the inputs, practices, and outputs across the projects, prioritised by the most frequent.

Table 10-9: Iterative Design and Development Inputs, Practices and Outputs

Case	2	3	4	5	6	7	8	9	Total

	1									
Inputs										
Design concept prototype	x		x	x	x			x		5
List of validated and prioritised customer needs		x						x		2
Procedure map, surgical workflow						x				1
Practices										
Surgeon co-design and evaluation of prototype	x	x	x	x	x	x			x	7
Evaluation and analysis of customer feedback from prototype (analysis for design options, brainstorming)	x		x		x	x		x		5
Developing design concept prototype (F&F, design language, testing)		x	x	x						3
Technology landscape search								x		1
Outputs										
Design concept prototype	x	x	x	x	x	x	x	x	x	9
Create the Design plan (design issues, killer questions)	x	x						x		3
List of identified, validated and prioritised customer need (usability needs)		x				x				2
Reduced scope prototype									x	1

Source: Author

10.3.1.7 Discovering Customer Insights

Eight case studies discovered insights during the FEI. Insights were discovered at two stages. Firstly, at an early stage, when the teams were either trying to understand the clinical problems or gathering the market research (observation videos, interviews, brainstorming ideas, finding pain points). These insights led to the identification of new customer needs. As can be seen in Table 10-10, seven projects discovered insights that led to new needs. Secondly, at a later stage, when the prototype design concept was created, the discussion moved to the functionality of the device. This led to the prototypes being revised and going through design iteration to include the insights. Table 10-10

provides a list of the inputs, practices, and outputs across the projects, prioritised by the most frequent.

It should be noted that eight case studies discovered insights; therefore, this may suggest that the discovery of insights is easy. However, the insights were not evaluated on the degree of value of benefit to the customer. The decision was taken that if the participant mentioned an insight, then the participant must have considered the insight valuable and beneficial. The number of insights that were discovered may also have to do with the uniqueness of the company in the case studies; this may be due to the industry, processes used, training or experience of the team. However, these variables still need to be investigated.

Table 10-10: Discovering Customer Insights Inputs, Practices and Outputs

	Case 1	2	3	4	5	6	7	8	9	Total
Inputs										
Design concept prototype	x	x	x	x	x					5
List of prioritised customer needs					x					1
Unmet clinical need (clinical value)						x				1
Practices										
Evaluation of prototype internally and with users (exploring uses)	x	x	x						x	4
Understanding the clinical and patient problems			x	x				x	x	4
Observing videos , interviews, brainstorming ideas, finding pain points, procedure and patient maps				x	x	x				3
Outputs										
Customer insights discovered and identified new needs from the insights	x	x		x	x	x		x	x	7
Design concept prototype		x	x	x	x					4
Discovered insights in other applications			x		x					2

Source: Author

10.3.2 Summary

In summary, seven insight discovery process FEI elements have been found in the innovation projects. Each project process was graphically compared to the other projects to determine the similarities and differences. These seven elements have been cross-referenced with the Koen *et al.* (2001) and Khurana and Rosenthal (1997) FEI models, which showed similarities across the three models. There were also novel differences; firstly, discovering insights was a significant activity in the case studies. However, these activities were grouped at a lower level in both the NPDFE and NCD models. Secondly, the NPDFE model has a product definition element, and the NCD model has idea genesis and idea selection elements. In the case studies, these activities were more focused on the development of the technology, discovering insights and problem-solving; as such, a more fine-grained view of the front end was seen. Thirdly, engaging with customers was mentioned in the descriptions of the NPDFE and NCD model element; the descriptions talked of market research and identification of customer needs; however, in the case studies, engaging with the customer was a substantial element in the process.

Furthermore, the inputs, practices, and output for each of the seven elements have been extracted from the case study data to provide a fuller picture of the FEI process. The seven elements are:

1. Project strategy
2. Understanding the unmet need
3. Technology development
4. Engaging with customers
5. Understanding the customer needs
6. Iterative design and development
7. Discovering customer insights

10.4 COMPARISON OF CUSTOMER INSIGHTS AND DESIGN INSIGHTS

The nine case studies provided examples of customer insights that were discovered during innovation projects. A total of 17 customer insights were discovered across the nine case studies. The insights were coded if the participants stated they were insights; no external evaluation of the insight value and benefit was performed. Differences in the insights can be seen from the retrospective and longitudinal case studies. The retrospective case studies discovered both the early stage and the later design concepting stage of the front end, whereas the longitudinal discovered insights at the early stage of the FEI. Table 10-11 provides an overview of the case studies and includes a brief descriptor and the number of insights for each study. The remainder of this section will discuss the customer insights and number of insights and associate these with the innovation project.

As shown in Section 10.3, the front end has been described by Field Koen et al. (2001) and Field Khurana and Rosenthal (1998) as having an opportunity assessment and strategy stage and an idea selection and development stage. These two stages can also be seen in the case studies' processes. Initially, the teams worked internally on the project strategy to understand the unmet need and then engaged customers to understand the unmet need further; this activity uncovered customer insights that influenced the unmet need and design. These customer insights may not have been discovered unless the team purposely engaged the customer to understand the problems they faced.

There was a difference in the forms of customer insights that were seen in the case studies; insights were found both in the early stage and the later stage. The earlier insights were based on market research, whereas the later design insights were centred around the prototype. In the early stage, the insights came from conversations and interviews with customers and observation of the customers. In the later stage, the conversations and interviews were future-oriented, as the team worked through the front end and started idea generation and design concept refinement. The teams had a design idea, concept or prototype and used these design artefacts to discuss improvements and bring out potential design issues. This led to the discovery of newer insights through internal design review meetings and engagement with customers in design meetings or cadaver labs where the

prototype concept was being evaluated. For instance, the Archway team investigated to deeply understand the unmet needs of what the customers wanted from a new product and the issues with existing solutions. During this process, the teams were able to discover insights that were included in the subsequent design iterations. By having the artefact available, the teams and customers could better envision the needs and how they were being solved. In reviewing these two forms of insights, comparing how and when they were discovered, it is proposed that the early-stage insights are termed 'customer insights', and the later-stage insights are termed 'design insights'.

The five retrospective cases discovered 11 customer insights; three customer insights were discovered in the early stage, and nine design insights were discovered in the later stage. Refer to Table 10-11 and the breakdown in the insights per case study. Though the later-stage insights were more recent in the project progress than the early-stage insights, the team were still able to recall the early customer insight. For instance, for Archway, the one-handed operation of customer insight was a clear benefit to the customer. It remained a crucial function of the device, and its discovery and evolution through the product remained a focus for the team. This was similar to the Barricade and Amalgam customer insights.

The four longitudinal cases discovered seven early-stage customer insights (1 Plexus, 0 Stanley, 3 Violet, and 3 Planetary). A possible reason Stanley did not discover any insights is that it was put on hold early in the front end, and the team needed the opportunity to engage with customers sufficiently. Additionally, all of the longitudinal projects were still waiting to discover any later-stage customer insights. This was because the projects were followed whilst they were in the early stage only and had yet to move into the design concept development stage. If these case studies were followed through 2023, then later-stage design insights may also have been discovered.

In summary, the teams engaged customers with the intention of discovering customer insights. The customer engagement defined two forms of insights found in the FEI: 1) insights from an initial understanding of the unmet need and 2) insights from an assessment of the design artefact.

Table 10-11: Case Study Comparison of Customer Insights

Data Collection Case Study Type	**Retrospective**					**Longitudinal**			
Case Study Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
PhD Project Code	**Spark**	**Archway**	**Barricade**	**Amalgam**	**Minerva**	**Plexus**	**Stanley**	**Violet**	**Planetary**
Early-Stage Customer Insights									
Title Early Insight 1		One-handed operation	Education on stress/strain	Combining surgical approaches		Flexibility in treatment	None	Infection control	Surgical confidence
Title Early Insight 2								Data concerns	Agnostic to technology
Title Early Insight 3								Data legal implications	Surgeon age difference
Later-Stage Design Customer Insights									
Title Later Insight 1	Risk factor tab	Force-to-fire	Dashboard view	Surgical process	Measure function				
Title Later Insight 2	Data - doers/real-thinkers				Too much technology assistance				
Title Later Insight 3					Dimmed camera light				
Total Number of Insights	2	2	2	2	3	1	0	3	3

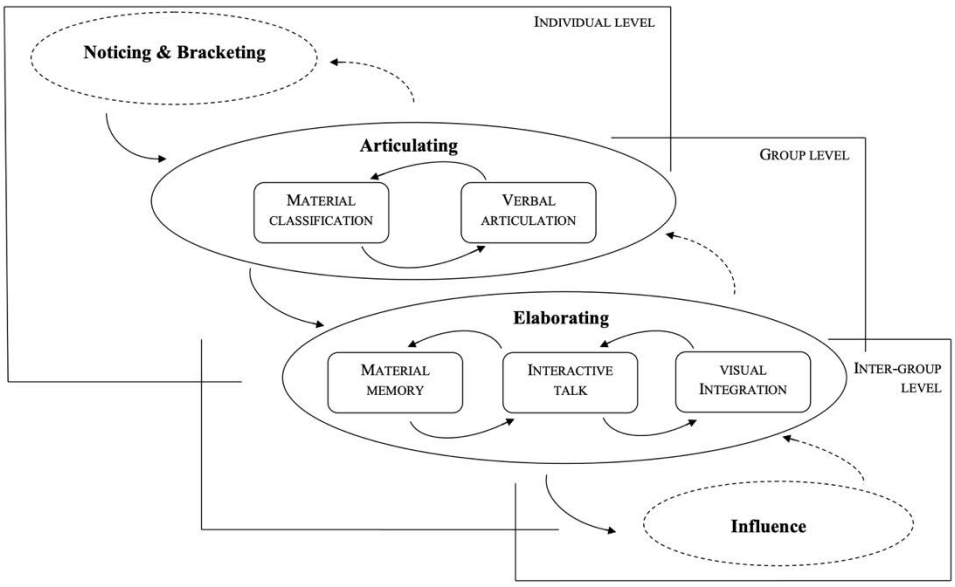
Source: Author

10.5 COMPARISON WITH COLLECTIVE SENSEMAKING MODEL

The theory of sensemaking was introduced in Section 3.6.2, and it was proposed that sensemaking was the most appropriate management theory for addressing RQ 2. Therefore, the research was compared to the collective future-oriented sensemaking process model (Stigliani and Ravasi, 2012). To apply this model to the current study, a detailed reading of the paper was performed to extract the key terms. These key terms are captured in the provisional sensemaking coding list in Appendix B.2.

The five retrospective case studies were analysed to understand how collective sensemaking is applied to the process of insight discovery. The five case study interviews (a total of 20 interviews) were coded against the sensemaking coding list (Appendix B.2). The outcome of the analysis is shown in the sensemaking data structure (Table 10-12), which lists the codes, the number of participants for each code and the responses for each code. The codes have been aggregated into the main themes of the paper and the four process cycles (shown in Figure 10-11); each of these will be discussed below. The sensemaking coding was additional and separate from the RQ 1 and RQ 2 coding.

Figure 10-4: Collective Sensemaking Process Model



Source: Adapted from Stigliani and Ravasi 2012.

Table 10-12: Sensemaking Data Structure

Name	Participants' Responses	Number of Codes
Main Theme	**19**	**94**
Ambiguity	1	1
Back and forward sensemaking - individual to group	9	22
Collective sensemaking	15	31
Future oriented	3	5
Gap between reality and expectations	8	13
Individual sensemaking	10	13
Prospective	1	1
Retrospective reflection	1	1
Sensmaking stopping - feeling the new order	5	6
Process Model Cycles	**20**	**258**
Noticing and Bracketing	**19**	**67**
Cues and triggers	10	15
Immersion in the task	10	12
Flux of experience	14	29
Provisional interpretations	9	11
Articulating	**20**	**62**
Imbued with meaning	3	5
List of features	8	9
Material practice	11	20
Metaphors	2	2
Product and prototypes	12	26
Elaborating	**20**	**105**
Brain dumping	6	7
Capturing ideas	9	14
Connecting brains	7	11
Elaborating	4	6
Integration of understanding	11	13
Iterations	10	18
New understanding	16	28
Organising thoughts	8	12
Visualisation	2	2
Influence	**12**	**23**
Interpretation - exchange, combine and construct	6	7
Persuade clients and customers	8	11

10.5.1 Main Theme

The central theme consisted of nine codes, with all nine being coded at least once. There was support for back and forward sensemaking between the individual and group; this was also maintained by individual sensemaking and collective sensemaking codes. These three codes operated collectively. Also, the coding showed that the participants recognised a gap between reality and expectations. Future orientated only had support from three participants from three different projects. The other three codes received limited support.

It can be proposed that the paper's central theme of collectiveness was supported. The future-oriented theme only had limited support; however, this may be due to product innovation being a future-oriented activity; therefore, it is fundamental and may not be directly mentioned.

10.5.2 Process Model Cycles

All 20 participants' comments were coded in the process model cycle codes: 1) noticing and bracketing, 2) articulating, 3) elaborating, and 4) influencing. The four codes in the noticing and bracketing cycle were supported. The participants reported that they were fully immersed in the task, and this led to new knowledge of the problems that the customer encountered. During the immersion activities, cues and triggers were noticed, and provisional interpretations were bracketed. The interpretations were then tested in later activities, such as observation of the customer and the creation of new interview questions to drive a deeper understanding of the problem.

The articulating cycle codes demonstrated that the teams predominantly articulate ideas and design concepts through prototyping and other material practices, such as PowerPoints and sketches. The prototypes could either be CAD images, 3D prints, machined or software (e.g., Figma.com). To a lesser extent, a list of features was also used to articulate ideas.

As shown by the number of codes, elaboration was the most involved process cycle reported by the participants. With 103 codes, this accounted for about two-fifths of the total number of process cycle codes (105/250 = 41%). As the team worked through the FEI, the design was modified to reflect a new understanding; this new understanding was

then built into the prototype's next iteration. This cycle of refinement afforded the teams the opportunity to integrate the new understanding into the prototype and test it at the following design meetings. The process hinged on the refinement of the prototype.

The final cycle, influence, showed a different level of support than the other three cycles. Only 12 of the 20 participants mentioned that a crucial part of the project was influencing internal staff and persuading customers of the merits of the ideas, concepts, and solutions. However, reviewing the coding does reveal that all five projects are represented by the 12 participants. None of the codes were from the marketing function; they were all from the development functions (engineering and industrial design).

10.5.3 Summary of the Collection Sensemaking Model

In summary, the coding of the five retrospective cases has demonstrated that aspects of the Collective Sensemaking Process Model proposed by Stigliani and Ravasi (2012) were found. However, the coding did not explore the links in the model. Stigliani and Ravasi (2012, p. 1240) did not clearly state the coding method and analysis that was used, so repetition in these cases was limited; 'we turned to axial coding to uncover the relationships'. However, the data analysis has shown that the main themes of the model and the process cycles are activities that innovation teams conduct in the FEI. There was evidence to support the individual, group, and inter-group levels of sensemaking and an iterative back-and-forth understanding and interpretation of new information. Therefore, the model does help to explain the cognitive aspect of the FEI.

10.6 INTEGRATING THE FEI PROCESS AND SENSEMAKING

The analysis of the discovery of customer insights and sensemaking was conducted independently of the data from the interviews. Integrating these two viewpoints is crucial for a fuller understanding of the discovery of customer insights and answering RQ 2.

The Collective Sensemaking Process Model (Section 10.4) is a cognitive process, and the discovery of the insight process in the FEI is a practical process. As these two viewpoints were both found in the data, it is proposed that these are complementary processes. Whereby the teams use their collective cognition (sensemaking) to execute the practices and produce the outputs (insight process). These are complementary because a

practical process without recognising the cognitive aspect would be akin to ‘cranking the handle’, producing outputs without a deep understanding of the customer and their problems. The cognitive aspect may account for the fuzziness of the front end that is still observed today. Furthermore, Stigliani and Ravasi (2012) emphasised that the use of material practices and the creation of artefacts enable abductive thinking in creative problem-solving. Therefore, fuzziness remains in the problem-finding and problem-solving processes.

10.7 SUMMARY OF CROSS-CASE ANALYSIS CHAPTER

Seven FEI process elements have been found in the cross-case analysis. The analysis also demonstrated that all projects started with the project strategy element, which led to understanding and defining the unmet clinical need. The following five elements then interacted throughout the front end process as each new piece of data changed the team’s understanding. Customer and design insights were discovered, and these were rooted in the market research and prototype design concept, which were then translated into newer customer needs. The project strategy lay at the heart of the process and was revised in line with new information. Once the technology challenges and customer feedback had been addressed, the team were able to finalise the prototype and customer needs list, which led to the final update of the project strategy and commencement of the NPD phase of product innovation. The chapter also showed, firstly, that there are two forms of insights within the FEI, customer insights and design insights and secondly, that the analysis supported sensemaking in product innovation. The final chapter (Chapter 11) will discuss and conclude the cross-case analysis for RQ 1 and RQ 2.

CHAPTER 11 DISCUSSION AND CONCLUSION

11.1 INTRODUCTION

Chapter 11 presents how the research has addressed the two research questions and, therefore, the gaps in the current literature that were identified in the SLR (Chapter 2). The chapter summarises the cross-case analysis and findings for RQ 1 (Chapter 7) and RQ 2 (Chapter 10). The main body of the chapter discusses the research and presents a framework for the discovery of customer insights. Finally, the theoretical and practical contributions, limitations and future research are considered.

Chapter 11 is organised as follows:

- Discussion
- Theoretical contributions
- Contribution to practice
- Limitations and future research
- Summary of the chapter

11.2 DISCUSSION OF THE RESEARCH

In the field of product innovation management, the FEI framework theories play a pivotal role in the success of new product development. At the core of these frameworks lies customer needs and insights, which are crucial for identifying and understanding the market. Gathering market research and analysing customer needs are essential activities in the front end, and there are several approaches to doing so, including surveys, focus groups, and ethnographic research. However, the exact role of customer insights in the front end, as well as their relationship to customer needs, needs to be clarified in the literature. Therefore, it is imperative to understand insights in the front end innovation process to gain a comprehensive understanding of the customer and market and develop successful products that fulfil needs and preferences.

The main objective of this research was to enhance our comprehension of the process of discovering customer insights in the FEI. This was accomplished by studying

innovation teams during the FEI. The study revealed that there was a good practical understanding of customer needs. Still, the connection between customer needs and insights needed to be clarified in the literature, although it was clearer in practice. Therefore, the FEI was investigated to determine how needs and insights are related.

A dual multi-case study was conducted to explore the current FEI frameworks and sensemaking. The results showed that needs and insights are critical components of the front end, which might need to be adequately emphasised in the existing FEI frameworks. The cases highlighted that significant resources were devoted to understanding their customers to uncover their needs and ultimately discover new insights. It was observed that innovation teams came to the FEI with a structured plan and a clear intention to discover new customer insights. They did not stumble upon these insights by accident. The teams carried out various activities to gain a deeper understanding of the customer, leading to the discovery of insights.

The findings of this research contribute to the existing knowledge of the FEI, offering an extended explanation of the activities carried out by teams in a medical device company. The research design, which collected both retrospective and longitudinal data and utilised an analysis process, confirms this explanation. Additionally, this study supports the prospective sensemaking model proposed by (Stigliani and Ravasi). The analysis reveals that innovation teams use this cognitive process to comprehend the FEI environment and share ideas. Further information on this can be found.

11.3 DISCUSSION OF RQ 1

The SLR (Chapter 2) found that the current literature does not sufficiently define customer insights. It found a good understanding of customer needs, but there were contradictions with customer insights. The definitions established by the literature review complemented each other and showed the customer's underlying values and the benefits the product provides to the customer. Table 11-1 shows the two d the SLR.

Table 11-1: Customer Need and Insight Definitions

Customer Need Definition (Section 2.5.2)	Customer Insight Definition (Section 2.6.1)
A statement crafted by the innovation. team that interprets the market research data and defines the customer's future benefit from and value of a product's use	A customer insight is an expression of deep knowledge about customers that leads to an actionable non-obvious solution

The SLR established a clear knowledge gap in respect of the relationship between the two constructs: customer need and customer insight. It was seen, from the reviewed literature, that customer insights have been discussed as a component of needs or a separate concept. Additionally, the sequence of needs and insights has only been examined by one author, (Carlgren, 2013). These issues cause a problem as researchers and practitioners use the same terms but are referring to different conceptualisations. The research attempted to understand the relationship between needs and insights further. Therefore, RQ 1 was developed to explore this relationship through case study research.

The findings from the research indicate that the participants possess a strong comprehension of what defines customer needs. However, they view customer insights as knowledge about the customer. After examining the definition of customer needs, all 20 participants concurred with the definition and could express a customer need in their own words. Conversely, when assessing the definition of customer insight, the participants disagreed with the definition. While they recognised that an insight requires a deep understanding, they did not view it as creative, non-obvious, or actionable.

In terms of their relationship, the participants regarded needs and insights as distinct concepts. Twelve participants believed that these are separate concepts, while ten claimed that they overlap. Three participants suggested that insights are a subset of needs. When it came to the sequence of needs and insights, ten participants felt that insights lead to needs, while only two believed that needs lead to insights.

11.4 DISCUSSION OF RQ 2

As shown in the literature review, the process of discovering insights is a crucial element of the FEI stage. However, the current literature does not provide a clear description of the relationship between customer needs and insights. The creativity and marketing

literature present different perspectives on the nature of insights. According to the creativity literature, insights stem from a process of problem-finding and problem-solving. In contrast, the marketing literature views insights as a deeper understanding of customer needs. These different conceptualisations of insights may be the reason for the confusion in the literature and practice. Since product innovation involves both marketing and creativity, this confusion may contribute to the fuzziness of the front end. Therefore, RQ 2 was developed to explore the process of discovering customer insights unfold within innovation teams.

11.4.1 Front End of Innovation and Sensemaking

Sensemaking is a crucial process in the FEI, where complex and ambiguous information needs to be interpreted and understood. This process helps innovation teams make sense of market research data and gain a better understanding of customer needs, technological possibilities, and the market. The findings of a study showed that innovation teams incorporate sensemaking activities, particularly future-oriented collective sensemaking, to understand complex information and find meaning. The team's collective experience enabled them to be comfortable navigating through the fuzziness of the front end. Only one participant reported discomfort with the unknowns, while others knew there were unanswered questions but had a plan to resolve them as they worked through the problems.

To understand the complex information and find meaning, various tangible design artefacts were created and used as vital communication tools at individual, group, and intergroup levels, both internally and externally. Early on, competitors and existing products were used to understand the customer challenges and pain points. As the FEI progressed, prototypes of increasing fidelity were used to communicate to users how identified needs were being addressed. This iterative cycle produced finer-level customer insights, which were required to reach a point where the design concept was sufficiently developed. The use of prototypes provided a focus for the conversation and enabled the exchange and combination of ideas. They came in various forms, such as physical concepts modified from existing products, 3D prints, CAD models, software wireframes, or fully functional designs representing the finished device. Crucially, they provided a route for communicating how the team interpreted insights into the product.

The study supported the future-oriented prospective sensemaking, and the data showed that the main themes of the model and the process cycles are activities that innovation teams conduct in the FEI. There was evidence to support the individual, group, and inter-group levels of sensemaking and iterative back-and-forth understanding and interpretation of new information. Sensemaking is a functional cognitive theory for interpreting and analysing how teams interact to solve complex problems and create novel solutions in the FEI. However, it only partially explains the FEI. The combination of a process framework together with the future-oriented prospective sensemaking model would provide a richer picture of the FEI.

11.4.2 Two Forms of Insights

The study found that eight out of nine case studies led to the discovery of insights. Further analysis showed that there were two forms of insights in the FEI, which were determined by the type of customer engagement. The first form was insights from the initial understanding of the unmet need, and the second form was insights from the assessment of the design artefact. Customer insights were discovered through conversations, interviews, and observation of customers, while design artefacts were utilised to discuss improvements and potential design issues. The insights from the design artefacts were embodied in the subsequent design iteration, enabling teams and customers to envision the problems better.

This more precise understanding of insights in the FEI helped to clarify tensions in the literature, in particular the difference between the creativity/psychology and marketing definitions of insights, as well as the approach of product innovation management and design theories to the FEI. In the creativity literature, insight is defined as a sudden comprehension or realisation leading to a new and creative solution. On the other hand, marketing defines insight as deep, actionable knowledge about the customers. This study identifies two forms of insight in the FEI: the marketing definition is applicable in the early stage when the team engages with the customer to understand the unmet need, and the creativity definition is relevant in the later stage when the team is finding non-obvious and creative solutions to design problems. As such, these two forms of insight occur at different stages within the front end.

Understanding the two forms of insights, customer insights and design insights, is crucial to understanding the FEI better. This understanding will assist teams in classifying the type of insight and communicating the insight. Customer insights will drive unmet needs, while design insight will drive customer needs and product design.

11.5 FORMING A FEI FRAMEWORK

The study of customer insights in the FEI and the engagement of innovation teams in the medical devices industry has helped produce a detailed account of the FEI (Front Innovation) process. This research has improved our understanding of this complex process and has established seven front end elements across nine case studies, as shown in Chapter 10. These elements can be formed into a FEI framework. The framework provides a more nuanced understanding of how innovation teams discover insights. It contributes to the overall understanding of the FEI process, which can help medical device innovation teams navigate the front end of the process by using the identified inputs, practices, and outputs.

In describing the process across the cases, the projects begin with a project strategy that includes defining an unmet clinical need. The innovation team then investigates and refines the unmet clinical need as new information is acquired, and the project strategy is revised accordingly. The other five elements interact throughout the front end process, and each new piece of data changes the team's understanding. Insights are discovered using the prototype design concept, which is then translated into newer customer needs. Once the technology challenges and customer feedback have been addressed, the team finalises the prototype and customer needs list, leading to the final update of the project strategy and the commencement of the NPD (New Product Development) phase of product innovation. The aim of each of the seven elements is defined as:

1. Project strategy

    - Project strategy begins with the strategic direction, including the business need, preliminary business case and an identified technology.
    - A budget is assigned, and the team is assembled, whereby they investigate and consider the literature, intellectual property, market, business case, and technology opportunities.

- The outcome is a revised project strategy with a defined unmet clinical need and technology direction.
- The project strategy is revised throughout the FEI process when new information is attained.

2. Understanding the unmet need
    - Understanding the unmet need is conducted after the initial project strategy.
    - Extensive market research begins, and preliminary customer needs are identified. Additional information is gathered on the market opportunities defined during the project strategy.
    - The unmet clinical needs may be revised in line with the identification of customer groups. The procedure map is created, and the design concept is begun.
3. Technology development
    - Analysis of the technology and associated risks; competitor technology search is conducted, with partnering activities, production of a proof-of-concept, and identification of a backup technology solution.
    - The technology landscape review is created.
4. Engaging with customers
    - Using the design concept and questions found from previous activities, the identified customer groups are engaged in the market research activities. Market research reports are compiled.
    - Create the preliminary customer needs list, feedback on the design concept prototype, design ideas, and storyboarding.
    - Revised procedure map and technology landscape review.
5. Understanding the customer needs
    - The market research reports, preliminary customer needs, procedure map and identified risks are used to refine and validate the customer needs.

- The design concept prototype is developed further in conjunction with the refined needs and simulated use.
- Customer needs are further validated and prioritised.

6. Iterative design and development
    - Ideas are chosen to be developed further to achieve the most value—iterative process throughout the FEI.
    - Development of the design concept prototype along with the refined list of customer needs. Development activities, such as co-design, design options and brainstorming, are used.
7. Discovering customer insights
    - The design concept prototype, the list of customer needs and the unmet needs are used to discover insights. This is done through ethnography, evaluations, and eliciting customer problems.
    - Insights are discovered throughout the process; early customer insights are based on understanding the needs, and later design insights are based on the design prototype.
    - New insights create new customer needs and are included in the list of needs to be validated and prioritised.

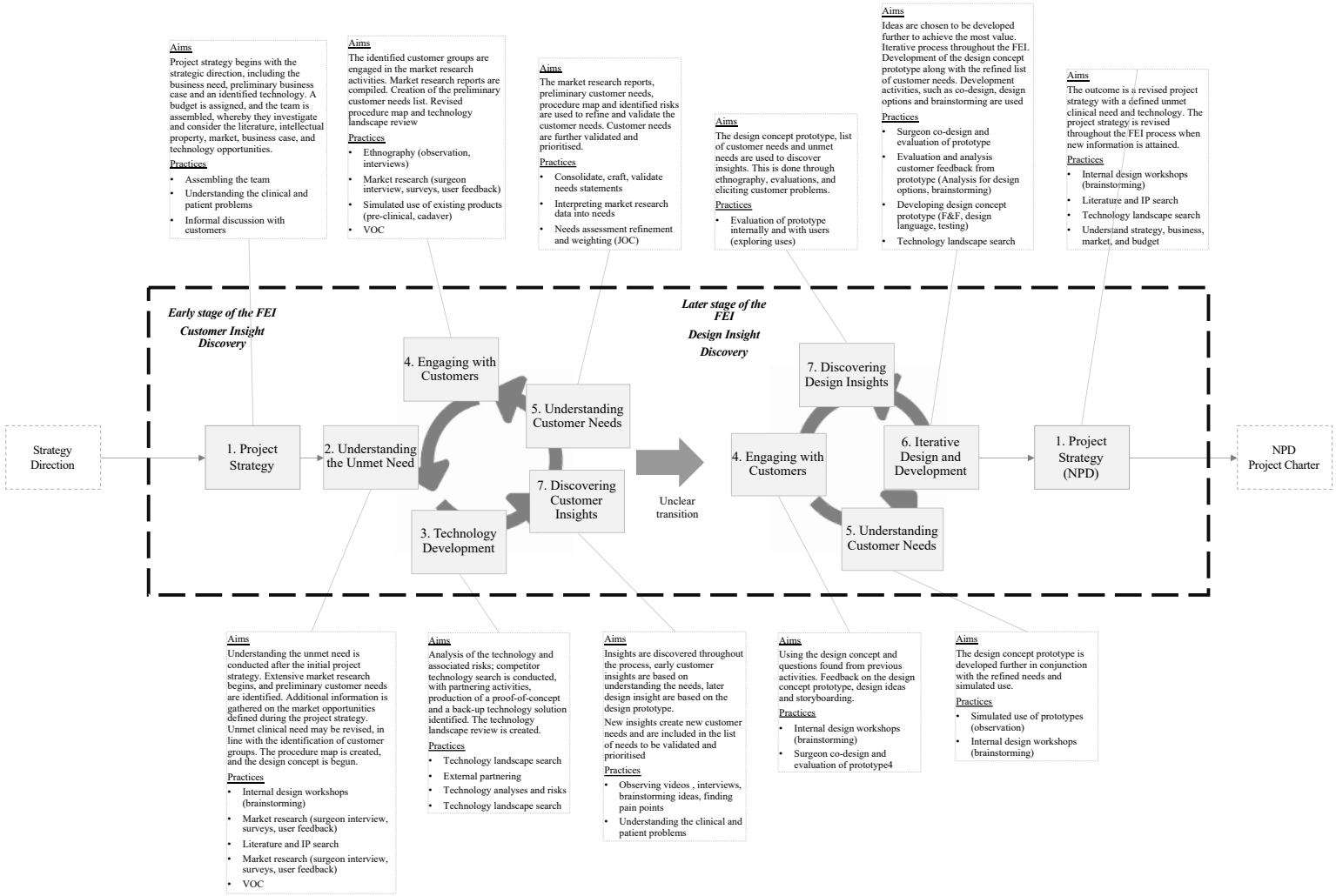
The discovery of customer insights is facilitated by an FEI framework comprising seven elements, represented in Figure 11-1. The framework begins with the business's strategic direction, which informs the project strategy. The project strategy then leads to the first element being the understanding of unmet needs. The early stage of customer insight discovery includes four other elements: engaging with customers, technology development, discovering customer insights, and understanding customer needs. These five elements are iterative and feed into each other until the team believes that they have gained enough knowledge of the customer and their needs.

Subsequently, the team transitions from understanding the customer's needs to the later stage of the FEI. The transition is not precisely determined in the data or findings,

but it involves moving from understanding the customer needs to the beginning of designing, concepting, and prototyping.

The design insight discovery stage includes four elements: engaging with customers, discovering design insights, understanding customer needs, and iterative design and development. Three elements are repeated from the first loop, and the design concept prototype is used to discover design insights, which makes the practices and outputs different within the elements. In this later stage, the technology is developed into the prototype, which increases in fidelity and is used to engage customers to elicit their feedback. Once the team believes that the prototype has reached an acceptable level of fidelity, the project strategy is finally refined, and the project is chartered to proceed from an FEI project to a New Product Development (NPD) project.

Figure 11-1: A Framework for the Discovery of Customer Insight in the FEI



11.6 IMPACT OF ARTIFICIAL INTELLIGENCE ON THIS THESIS

Customer needs and insights are a dynamic field. Of particular recent interest is the phenomenon of AI and how this is being brought into the innovation process, especially the FEI. On that basis, I briefly reviewed the literature on customer needs and insights to understand the extent to which the current research feeds into the ongoing debate.

Recent developments in the research into customer insights have seen the emergence of artificial intelligence (AI) and machine learning (ML). Integrating artificial intelligence in product innovation management, particularly for gaining customer insights, is becoming indispensable for companies seeking to enhance customer engagement and drive business growth (Tanev and Sandstrom, 2019; Verma *et al.*, 2021). This summary provides an understanding of the role of AI in discovering customer insights for product innovation.

AI, big data, and the associated digital economies have transformed modern societies, creating opportunities for organisations to understand their customers better (Holmlund *et al.*, 2020). With social media producing vast amounts of data, businesses have the potential to analyse extensive data sets to gain new customer insights and make better decisions (Plannger *et al.*, 2023; Mahajan, 2023). Using AI to data-mine is considered one of the most essential tools for achieving these goals. This has been described as a process of uncovering hidden patterns and finding previously unseen connections or irregularities. The analysis incorporates mining for sentiment analysis and social media analytics. Social media analytics is particularly crucial in modern dynamic operational environments. (Mach-Król and Hadasik, 2021)

AI-driven customer analytics enable businesses to offer personalised experiences, building brand loyalty and driving growth (Fernon, 2021). The shift from relying on cookies to using AI models and analytics tools has allowed companies to integrate diverse data sources, create comprehensive customer profiles, and predict decisions (Nuseir, McKenna and Harrington, 2020). These profiles enable companies to generate insights, test hypotheses, and run experiments tailored to business objectives. Application examples include Accenture's C360 platform, which illustrates how AI can be used to

create detailed consumer profiles, predict customer behaviour, and enhance engagement (Fernon, 2021). AI capabilities and analytics tools enable companies to understand their customers at a granular level (Renno, Sheng and Wang, 2022). AI assists innovation teams by providing insights into customer needs. Furthermore, tools like RapidMiner and Google's AutoML Tables have the potential to revolutionise customer research (Mahajan, 2023).

AI algorithms offer data-driven insights for strategic decision-making, automating routine tasks to focus on strategic and creative aspects (Mustak *et al.*, 2021). However, successful AI integration requires a team with machine learning and data science expertise to ensure quality data for training AI algorithms. Regular updates and maintenance are vital for AI systems to remain relevant and perform optimally (Mahajan, 2023). AI-driven insights modules and customer behaviour analysis tools help understand customer behaviour and preferences, aiding in design and product decisions and market opportunities (Verganti, Vendraminelli and Iansiti, 2020). Automated data analytics dashboards and AI-powered product roadmap optimisers streamline the product development process (Renno, Sheng and Wang, 2022).

AI integration is pivotal for creating more personalised and practical solutions, augmenting human capabilities rather than replacing them. AI's integration in customer success applications marks a shift towards more tailored product development and predictive analytics for customer engagement. Critical capabilities for leveraging AI include effective product architecture, feedback loops, and tracking customer engagement throughout the journey (Fernon, 2021).

Despite its potential, AI deployment at scale faces technical and organisational challenges, with many companies still in the early stages of fully realising AI's benefits. The next generation of AI tools offers more autonomous operation and fine-grained insights, leading to personalisation and informed business decisions. Addressing ethical and legal considerations is crucial in AI integration, focusing on transparency and data security (Fernon, 2021).

AI's role in discovering customer insights for product innovation management is multifaceted, offering significant advantages in customer engagement, strategic decision-making, and product development (Brem, Giones and Werle, 2023). Its ability to process

and analyse vast amounts of data enables businesses to create more personalised and compelling customer experiences. However, realising AI's full potential requires investment in technology infrastructure, skilled teams, and continuous updates, along with addressing ethical and legal considerations. The future of product management and customer success is deeply intertwined with the advancements in AI technology (Baines *et al.*, 2023). For example, Timoshenko and Hauser (2019) suggested a user-generated content process for addressing the problem of identifying customer needs; instead of direct engagement (interviews, surveys, etc), machine learning would gather the needs from a database. They found that machine learning was comparable to human analysis and was more efficient.

The nascent research into AL, ML and extensive data mining can provide significant benefits to discovering customer insights. Though data analysis is essential for uncovering needs and insights, other activities are just as crucial. The social-political aspect of insights, such as the socialisation step in the SECI model Field (Nonaka, Toyama and Konno, 2000), requires consideration of how AI will impact the human interactions (Bouschery, Blazevic and Piller, 2023). Furthermore, the importance of creativity in discovering insights is hard to judge, as well as how the resultant insights and ideas are evaluated. This recent generation of AI will initially be most beneficial to gain an overview of explicit (stated needs) across many data sources. However, the unarticulated (hidden) needs will require further understanding and development of AI technology.

This literature review and research study into customer needs and customer insights remain relevant. Innovation teams will still use the provided definitions and the methods and tools to gather the data for AI to mine. As this PhD research is ending in the same year (2023) as Generative AI becomes a reality, its impact still needs to be fully understood from a social perspective, as well as how it will genuinely impact product innovation and customer insight research. Future research into the behavioural and political side, as well as AI tools, will need to be undertaken to understand its impact better.

11.7 THEORETICAL CONTRIBUTIONS

This investigation explores the discovery of customer insights through the lenses of FEI and sensemaking, providing a perspective of how FEI is conducted with medical device innovation teams. A dual-method approach was employed to build on the FEI domain. Previous studies into customer needs and insights have yet to utilise this approach, which combines both retrospective and longitudinal research. This approach mitigates the risk that cases would not discover customer insights. Furthermore, it provides data on innovation projects from both retrospective and longitudinal perspectives. The retrospective case studies give a historical view of completed projects, while the longitudinal case studies provide the opportunity to explore how insights are discovered during FEI dynamically. By taking a longitudinal approach, researchers get closer to the phenomenon of interest than using only the retrospective approach, as it allows the study of a case at three different time points. Combining retrospective and longitudinal case studies reduces the likelihood of recollection bias, allowing for the collection of dynamic data that reveals how projects changed over time.

This research also contributes to sensemaking in product innovation by investigating the cognitive aspect of the process of discovering customer insights. In doing so, it advances the understanding of the process. Additionally, it responds to the call for sensemaking research in product innovation and creativity, building on intragroup creative sensemaking in product innovation, which situates the future collective process with retrospective iterative cycles.

Finally, the research extends the understanding of FEI, contributing to earlier work. It builds on the elements previously identified by Koen et al. (2001), Khurana and Rosenthal (1998) and others. It has shown these elements are also present in medical device innovation projects. The current study extends the existing frameworks by identifying additional elements and providing additional process details of the inputs, practices, and outputs of each of the elements in medical device innovation.

11.8 CONTRIBUTION TO PRACTICE

The research findings have several implications for medical device innovators. The study findings suggest three areas: 1) understanding the definitions of customer needs and

insights, 2) recognising the relationship between needs and insights, and 3) the retrospective and longitudinal approach, 4) the process of discovering customer insights.

Firstly, it is crucial to have a clear understanding of the definitions of customer needs and customer insights to ensure clarity within the team and with managers. By better classifying customer needs and customer insights, further categorisation of the type of product innovation, such as radical and incremental, could be achieved. As suggested (Ulwick, 2002; Goffin and Lemke, 2004), gathering only customer needs can lead to incremental innovation, but the discovery of customer insights may lead to radical innovation. As stated in the prospective sensemaking model, the ability to communicate the needs and insights within the team and to the customer is also critical to success. Additionally, the research suggests that there may be two forms of insights in the FEI framework – customer insights and design insights. Customer insights are discovered at the early stage when the team analyses market research and engages with customers to explore their problems. Design insights are discovered when a concept design prototype is available, and the team starts to explore design options. This knowledge will assist teams in properly classifying the type of insight. Therefore, a commonly agreed-upon definition of needs and insight is crucial to project success.

Secondly, the finding suggests that by understanding the relationship between customer needs and customer insights, a story can be constructed. This story could illustrate how the final product was achieved, showing the flow from the market research, the unmet need, the customer insight, prototype design concept, through to customer needs, design insights, and eventually to the marketed product. Also, the research demonstrated that needs and insights are separate concepts and do interact with each other. As such, teams should approach the analysis of market research intending to discover insights using various cues and triggers (overgeneralisation, workarounds, metaphorical glosses, claims of idiosyncrasy, and triggers of use).

Thirdly, during the research, two approaches were taken: retrospective and longitudinal. The retrospective data suggested that the innovation teams may have overlooked the iterative nature of the front-end process. This could be due to either not remembering the minor iterations or not considering them important enough to be discussed during the interview. Conversely, the longitudinal research approach followed

the teams throughout the front-end process, making it easier to recall and discuss minor iterations and path corrections. As a result, the retrospective case studies presented a more linear process flow, while the longitudinal approach showed an iterative process.

Finally, the FEI framework can be used by medical device companies to design their in-house FEI process or be used by innovation teams as a guide through the FEI. The elements, associated inputs, practices, and outputs should be chosen carefully or experimented with by the team. They should not be used as a checklist of activities to be followed blindly in the hope that insights and needs pop out at the backend. Imposing a level of control and bureaucracy on the FEI could diminish the creativity and free experimenting necessary for radical innovation.

11.9 LIMITATIONS AND FURTHER RESEARCH

This section presents the limitations of the research and the potential future research opportunities.

11.9.1 Limitations

Although the research was carefully designed to consider reliability, validity and generalisability, there remain a number of limitations.

11.9.1.1 Generalisability

While the research attempts to provide generalisable results and conclusions that can be applied to various cases and industries, this is challenging as the study has only focused on a single industry and company. To assess the extent to which the research can be generalised, four levels of generalisation can be considered: the company level, the medical device industry level, the existence of country-specific disparities, and the level of product innovation management theory.

The findings from the nine case studies conducted within the medical device division of the company can be applied within the company itself. Still, the level of generalizability is relatively low (Watson *et al.*, 2017).

Considering the implantable medical device segment, standards and regulations are uniform, and organisations share similar characteristics. As a result, these findings could

also be helpful for other medical device companies, particularly those that design and develop comparable devices, such as orthopaedic, surgical, and wound care products—representing a low to medium level of generalisation (Watson *et al.*, 2017). However, for manufacturers of diagnostic or large-capital medical devices (such as MRI or CAT machines), the findings have reduced generalizability. The framework may need to be further investigated in these settings to increase the generalisability.

Considering the varying country contexts, the literature examined cases spanning four continents: North America, Europe, Asia, and Australia. A total of six studies analysed cases from multiple countries and continents, focusing on the US, UK, Germany, and Japan. For this research, the cases were drawn from four countries: the UK, the US, France, and Switzerland. The selection of cases across these geographical regions, mirroring the literature, has enhanced the robustness and generalizability of the findings by minimising the impact of cultural differences that may arise from analysing a single-country case. (Kahn *et al.*, 2012).

Achieving generalizability in the realm of product innovation presents a significant challenge. While certain aspects may bear some resemblance, it is essential to recognise the inherent uniqueness of the various customer groups (in this research, which includes surgeons, physicians, nurses, hospital staff, and patients), cultures, and existing industry innovation processes and technologies. As such, generalisability in product innovation cannot be claimed.

The framework will require testing in other contexts and settings to establish validity and generalisability. The hope is that it is tested first in other medical device companies and then broadened to diverse settings, such as consumer goods or manufacturing organisations.

11.9.1.2 Other limitations

1. The study used a broad approach to data collection. This broad approach involved engaging with nine different project innovations. The alternative approach would have been to delve deep into a single case to provide a more nuanced understanding of the team's interaction, emotions, and insight discovery process. Rather than relying on interviews at specific time points, the researcher could have observed day-to-day interactions within the innovation team, as demonstrated in

a previous study (Stigliani and Ravasi, 2012). However, due to the limited scope of a part-time PhD, the researcher was unable to observe and spend time within a company.

2. Data collection. A sole researcher obtained the data; other researchers may have had alternative understandings and inquiries through the data collection. Despite utilising two data sources, the inclusion of external and internal design meetings for observation could have broadened the dataset.
3. Longitudinal data collection. The scope of data acquisition for the longitudinal cases was delimited to a duration of ten months owing to the time constraints of the PhD program. The acquisition of more comprehensive data pertaining to the process of insight discovery may have been attainable had the longitudinal studies followed through until the year 2023.
4. Data analysis. The data was not coded by an additional researcher, thereby precluding the execution of inter-coder reliability measures. Only one researcher performed the coding, thus augmenting the potential for researcher bias. Had additional researchers been involved in the coding, inter-coder reliability would have been enhanced, and the impact of researcher bias mitigated.
5. Comparability across cases. The retrospective and longitudinal cases had different periods of data collection; as such, cross-case comparisons of the data and the resultant findings are challenging. Future research could assist in addressing this limitation.
6. Insight evaluation. The assessment of the value and usefulness of insights has yet to be fully explored. To comprehensively evaluate the worth and benefit of these insights, a longitudinal study that tracks their journey from the NPD phase to the marketplace could be helpful. However, due to the time constraints of a PhD, it is not feasible to track the insights over multiple years.
7. The research findings have yet to be shared with the case study innovation teams. The research only collected data on their current process. This validation phase was outside the scope of this particular study. In the future, action research(Coughlan and Coghlan, 2002) could be conducted on the framework with similar teams.

11.9.2 Further Research

The study has revealed both the contributions and limitations of the research, highlighting several areas that require further investigation. A study across different industries, products and countries is necessary to establish external validity and generalisability.

1. For external validity and generalizability, a study encompassing various industries, products, and countries is necessary. The proposed test framework involves action research, with a longitudinal study tracking teams through the front end.
2. This study could have two strands, one following the company's existing process and the other employing the suggested framework, to compare outcomes and enhance replication. The framework's efficacy could be evaluated by assessing the number and quality of insights, either validating or challenging it.
3. A complete ethnographic study with an innovation team working through FEI could enable comprehensive research. Still, it would require greater access to confidential information, with multiple on-site visits over an extended period.
4. Investigating the two forms of insights in the FEI, customer insights and design insights, and how they drive design and relate to customer needs is an area that requires further research.
5. An additional researcher coding of the data from the present research could increase its validity.
6. The study has adopted a perspective using an FEI and sensemaking lens, though other theoretical perspectives, such as knowledge management, could be used.
7. The two primary documents produced in the FEI process, the requirements matrix and the Target Product Profile, could be analysed to understand how the team constructs the needs statements. One could then compare these to the ideal needs and insights from the literature and this research.
8. As this PhD research is ending in the same year (2023) as Generative AI becomes a reality, its impact still needs to be fully understood from a social perspective, as well as how it will impact product innovation and customer insight research. Future research into the behavioural and political side, as well as AI tools, will need to be undertaken to understand its impact better.

11.10 SUMMARY OF DISCUSSION AND CONCLUSION CHAPTER

Chapter 11 presents the discussion and conclusion of this thesis. It has offered answers to the knowledge gaps found in the literature, and it has provided a discussion on the broader implications. The research provided a framework for the discovery of customer insights and suggested that insights come in two forms: customer insights and design insights. Further, the framework provides seven FEI elements and the associated inputs, practices, and outputs for each of them.

The methodological contributions of the research include case study selection using both retrospective and longitudinal approaches and extending sensemaking theory in product innovation. The managerial implications include a revised FEI framework, an improved comprehension of the definitions for customer needs and customer insights, and a better understanding of the relationship between these two concepts. Finally, the chapter assessed the limitations of the research and offered some suggestions for future research.

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Appendix A – Systematic Literature Review

A.1 Inclusion and Exclusion Criteria

Inclusion Criterion	**Rationale**
Scholarly (peer-reviewed) journal publication	A peer-reviewed journal is likely to be of higher quality compared to non-scholarly types of publication such as working papers, dissertations, or conference proceedings.
Any publication date from 1990 to 2018	The key customer needs literature is from this date.
Theoretical, conceptual, or empirical papers	Although empirical research might constitute the most common approach to the phenomenon being studied, theoretical and conceptual publications play an essential role in advancing our knowledge in the field.
Practitioner publications, Conference publications, newspapers, trade journals, webpages, books, theses	The understanding of customer needs and insights remain a nascent field with limited journal publications, therefore practitioner publication may contain value information.
All countries	The review aims to offer insights into the international academic discourse on the topic being examined, thereby presenting literature concerned with a variety of geographical contexts.
Papers focusing on the psychology of insight generation and creativity	In addition to the product development and product innovation management (PIM) areas, psychology may also have key information on insights generation.
Papers focusing on market/consumer research	Market research may also have key information on insights generation.
Any journal rating is acceptable.	3 and 4-star journals emphasise quantitative research; 1 and 2-star academic journals may have relevant information. Practitioner journals do not have a star rating, but these publications may make a valid contribution.
Exclusion Criterion	**Rationale**
Journal title	Journals in fields not covered by this review, such as counselling, behavioural, developmental, education, tourism, politics, economics, finance, and foreign language.
Publication in a non-English language	A publication in a non-English language may not be accessible to a wider audience, thus possibly jeopardising the transparency and replicability of the review.
Literature or book review	The original publication will be used if deemed valid.
Company or industry level of analysis	The generation of customer needs and insights is not conducted at these levels within a company.
Paper that does not discuss the front-end of product development	Papers that discuss activities after the front-end are not relevant, as the customer needs and insights are already generated.
Papers that focus on product requirements generation.	Product requirement generation is after the creation of customer needs and insights; therefore, this is not relevant.

Source: Author

A.2 List of SLR Publications with Field and Journal

Reference	Title	Publication/Journal	Journal Field	Focus Area	Article type	Research Method
Guilford, 1959	Creativity	The American Psychologist	Psychology	Creativity	Conceptual	Conceptual
Holt, 1984	Need Assessment, a key to user-oriented product innovation	BOOK: Chichester: John Wiley & Sons, Ltd.	Management	Customer needs	Book	Book
Kano, 1984	Attractive quality and must-be quality	Quality, The Journal of Japanese Society for Quality Control	Production/quality	Customer needs	Conceptual	Conceptual
Gibson, 1986	The ecological approach to visual perception. Chapter 8 - Theory of Affordances	Psychology Press	Psychology	Customer needs	Conceptual	Conceptual
von hippel, 1986	Lead users: A source of novel product concepts	Management Science	Management	Market Research	Conceptual	Conceptual
Cooper and Kleinschmidt, 1987	Success factors in product innovation	Industrial Marketing Management	Marketing	Customer needs	Empirical	Quantitative
Hauser and Clausing, 1988	The house of quality	Harvard Business Review	Management	Customer needs	Conceptual	Conceptual
von hippel, 1989	New product ideas from lead users	Research-Technology Management	Innovation	Market Research	Conceptual	Conceptual
Cooper, 1990	Stage-gate systems: A new tool for managing new products	Journal of Product Innovation Management	Innovation	Innovation	Conceptual	Conceptual
Pugh, 1991	Total Design	BOOK: Addison-Wesley	Innovation	Innovation	Book	Book
Wallendorf and Arnould, 1991	We gather together	Journal of Consumer Research	Marketing	Market Research	Empirical	Qualitative
Buchanan, 1992	Wicked problems in design thinking	Design Issues	Design	Design Theories	Conceptual	Conceptual
Ciccantelli and Magidson, 1993	FROM EXPERIENCE: Consumer Idealized Design: Involving Consumers in the Product Development Process	Journal of Product Innovation Management	Innovation	Market Research	Conceptual	Conceptual
Griffin and Hauser, 1993	The voice of the customer	Marketing Science	Marketing	Customer needs	Empirical	Quantitative
Arnould and Wallendorf, 1994	Market-oriented ethnography: Interpretation building and marketing strategy formulation	Journal of Marketing Research	Marketing	Market Research	Empirical	Qualitative
Bower and Christensen, 1995	Disruptive technologies: Catching the wave	Harvard Business Review	Management	Innovation	Conceptual	Conceptual
Davidson, 1995	The suddenness of insight	BOOK: In the nature of insight p 125-155	Psychology	Insights	Book	Book
Zaltman and Coulter, 1995	Seeing the voice of the customer: Metaphor-based advertising research	Journal of Advertising Research	Marketing	Market Research	Conceptual	Conceptual
Griffin and Page, 1996	PDMA success measurement project: Recommended measures for product development success and failure	Journal of Product Innovation Management	Innovation	Innovation	Empirical	Quantitative

Reference	Title	Publication/Journal	Journal Field	Focus Area	Article type	Research Method
Simon, 1996	Sciences of the Artificial	BOOK: MIT Press	Management	Design Theories	Book	Book
Amabile, 1997	Motivating creativity in organizations	California Management Review	Management	Creativity	Empirical	Qualitative
Christensen, 1997	The innovator's dilemma	BOOK: Cambridge: Harvard Business School Press	Management	Innovation	Book	Book
Khurana and Rosenthal, 1997	Integrating the fuzzy front end of new product development	MIT Sloan Management Review	Management	Front-end	Empirical	Qualitative
Leonard and Rayport, 1997	Spark innovation through empathic design.	Harvard Business Review	Management	Design Theories	Conceptual	Conceptual
Reinertsen and Smith, 1997	Managing the design factory: A product developer's toolkit	BOOK: Simon and Schuster	Innovation	NPD	Book	Book
Thompson, 1997	Interpreting consumers: A hermeneutical framework for deriving marketing insights from the text of consumers consumption stories	Journal of Marketing Research	Marketing	Insights	Empirical	Qualitative
Amabile, 1998	A model of creativity and innovation in organisations	Research in Organizational Behaviour	Management	Creativity	Conceptual	Conceptual
Durgee, O'Connor, and Veryzer, 1998	Using mini-concepts to identify opportunities for really new product functions	Journal of Consumer Marketing	Marketing	Market Research	Conceptual	Conceptual
Khurana and Rosenthal, 1998	Towards holistic front ends in new product development	Journal of Product Innovation Management	Innovation	Front-end	Empirical	Qualitative
Matzler and Hinterhuber, 1998	How to make product development projects more successful by integrating Kano's model of customer satisfaction into quality function deployment	Technovation	Innovation	Customer needs	Conceptual	Qualitative
Slater and Narver, 1998	Customer-led and market-orientated: let's not confuse the two	Strategic Management Journal	Management	Customer needs	Conceptual	Conceptual
Veryzer, 1998	Key factors affecting customer evaluation of discontinuous new products	Journal of Product Innovation Management	Innovation	Innovation	Empirical	Qualitative
Cooper, 1999	From experience: the invisible success factors in product innovation	Journal of Product Innovation Management	Innovation	Customer needs	Conceptual	Conceptual
Mariampolski, 1999	The power of ethnography	Journal of the Market Research society	Marketing	Market Research	Conceptual	Conceptual
Patnaik and Becker, 1999	Need finding: The why and how of uncovering people's needs	Design Management Journal	Design	Customer needs	Conceptual	Conceptual
Reinertsen, 1999	Taking the fuzziness out of the fuzzy front end	Research-Technology Management	Innovation	Front-end	Conceptual	Conceptual
Simonton, 1999	Origins of Genius	BOOK: Oxford: Oxford University Press.	Management	Creativity	Book	Book
Avital and van Osch, 2000	The Generative Archetypes of Idea Work	Advances in Appreciative Inquiry	Psychology	Creativity	Conceptual	Literature review
Cristiano, Liker, White, 2000	Customer-driven product development through quality function deployment in the U.S. and Japan	Journal of Product Innovation Management	Innovation	Customer needs	Empirical	Quantitative

Reference	Title	Publication/Journal	Journal Field	Focus Area	Article type	Research Method
Letelier, Spinosa and Calder, 2000	Taking an expanded view of customers ' needs: Qualitative research for aiding innovation	Marketing Research	Marketing	Customer needs	Conceptual	Conceptual
Mascitelli, 2000	From experience: Harnessing tacit knowledge to achieve breakthrough innovation	Journal of Product Innovation Management	Innovation	Innovation	Literature review	Literature review
Rust and Oliver, 2000	Should we delight the customer	Journal of the Academy of Marketing Science	Marketing	Customer needs	Conceptual	Conceptual
Danneels and Kleinschmiddt, 2001	Product innovativeness from the firm's perspective: Its dimensions and their relationship with project selection and performance	Journal of Product Innovation Management	Innovation	Innovation	Empirical	Quantitative
Karkkainen et al., 2001	Assessment of hidden and future customer needs in Finnish business-to-business companies	R&D Management	Innovation	Customer needs	Empirical	Quantitative
Koen et al., 2001	Providing clarity and a common language to the "fuzzy front end.	Research-Technology Management	Innovation	Front-end	Empirical	Quantitative
Krishnan and Ulrich, 2001	Product development decisions: A review of the literature	Management Science	Management	NPD	Literature review	Literature review
Simonton, 2001	The psychology of creativity: A historical perspective	History of Creativity Research	Creativity	Creativity	Literature review	Literature review
Cooper, Edgett and Kleinschmidt, 2002	Optimizing the stage gate process	Research-Technology Management	Innovation	Innovation	Conceptual	Conceptual
Garcia and Calantone, 2002	A critical look at technological innovation typology and innovativeness terminology: A literature review	Journal of Product Innovation Management	Innovation	Innovation	Conceptual	Literature review
Gatignon et al. 2002	A structural approach to assessing innovation: construct development of innovation locus, type, and characteristics	Management Science	Management	Innovation	Empirical	Quantitative
Karkkainen and Elfvengren, 2002	Role of careful customer need assessment in product innovation management	International Journal of Production Economics	Production/quality	Customer needs	Empirical	Quantitative
Prahalad and Ramaswamy, 2002	The co-creation connection	Strategy and Business	Management	Customer needs	Conceptual	Conceptual
Ulwick, 2002	Turn customer input into innovation	Harvard Business Review	Management	Customer needs	Conceptual	Conceptual
Ulwick, 2003	The strategic role of customer requirements in innovation	White paper - Strategyn Inc.	Management	Customer needs	Conceptual	Conceptual
Bettencourt and Ulwick, 2004	The customer-centred innovation map	Harvard Business Review	Management	Market Research	Conceptual	Conceptual
Bohm, 2004	On Creativity	BOOK: Routledge	Creativity	Creativity	Book	Book
Callahan and Lasry, 2004	The importance of customer input in the development of very new products	R&D Management	Innovation	Customer needs	Empirical	Quantitative
Danneels, 2004	Disruptive technology reconsidered: A critique and research agenda	Journal of Product Innovation Management	Innovation	Innovation	Conceptual	Literature review
Elfvengren et al., 2004	A GDSS based approach for the assessment of customer needs in industrial markets	International Journal of Production Economics	Production/quality	Customer needs	Empirical	Quantitative

Reference	Title	Publication/Journal	Journal Field	Focus Area	Article type	Research Method
Goffin and Lemke, 2004	Uncovering your customer's hidden needs	European Business Forum	Management	Customer needs	Conceptual	Conceptual
Kristensson, Gustafsson and Archer, 2004	Harnessing the creative potential among users	Journal of Product Innovation Management	Innovation	Market Research	Empirical	Quantitative
Matthing, Sanden and Edvardsson, 2004	New service development: Learning from and with customers	International Journal of Service Industry Management	Marketing	Innovation	Literature review	Literature review
Narver, Slater and MacLachlan, 2004	Responsive and Proactive Market Orientation and New Product Success	Journal of Product Innovation Management	Innovation	Customer needs	Empirical	Quantitative
Urban, Hauser, 2004	Listening In to Find and Explore New Combinations of Customer Needs	Journal of Marketing	Marketing	Customer needs	Empirical	Quantitative
Tidd, Bessant, and Pavitt, 2005	Managing innovation integrating technological, market and organizational change	BOOK: John Wiley and Sons Ltd	Management	Innovation	Book	Book
van Kleef, van Trijp and Luning, 2005	Consumer research in the early stages of new product development: A critical review of methods and techniques	Food Quality and Preference	Management	Market Research	Conceptual	Conceptual
Veryzer, de Mozota, 2005	The impact of user-oriented design on new product development: an examination of fundamental relationships	Journal of Product Innovation Management	Innovation	Design Theories	Conceptual	Conceptual
Wills, 2005	The management and communication of customer insight	Interactive Marketing	Marketing	Insights	Conceptual	Conceptual
Arnould and Price, 2006	Market-oriented ethnography revisited	Journal of Advertising Research	Marketing	Market Research	Empirical	Qualitative
Cropley, 2006	In praise of convergent thinking	Creativity Research Journal	Creativity	Creativity	Conceptual	Literature review
Hargadon and Bechky, 2006	When Collections of Creatives Become Creative Collectives: A Field Study of Problem Solving at Work	Organization Science	Management	Creativity	Empirical	Qualitative
Rosenthal and Capper, 2006	Ethnographies in the Front End: Designing for Enhanced Customer Experiences	Journal of Product Innovation Management	Innovation	Market Research	Empirical	Qualitative
Smith, Wilson, and Clark, 2006	Creating and using customer insight: 12 rules of best practice	Journal of Medical Marketing	Marketing	Insights	Conceptual	Conceptual
Arthur, 2007	The structure of invention	Research Policy	Management	Innovation	Conceptual	Conceptual
Beckman and Barry, 2007	Innovation as a Learning Process: Embedding Design Thinking	California Management Review	Management	Design Theories	Conceptual	Literature review
Buijs, 2007	Innovation leaders should be controlled schizophrenic	Creativity and Innovation Management	Creativity	Innovation	Conceptual	Conceptual
Florin et al., 2007	Harnessing the power of consumer insight	Journal of Product and Brand Management	Marketing	Insights	Conceptual	Conceptual
Roberts, 2007	Managing invention and innovation	Research-Technology Management	Innovation	Innovation	Conceptual	Conceptual
Brown, 2008	Design thinking	Harvard Business Review	Management	Design Theories	Conceptual	Conceptual
DeYoung, Flanders, and Peterson, 2008	Cognitive abilities involved in insight problem solving: An individual differences model	Creativity Research Journal	Creativity	Creativity	Empirical	Quantitative

Reference	Title	Publication/Journal	Journal Field	Focus Area	Article type	Research Method
Ulwick and Bettencourt, 2008	Giving customers a fair hearing	MIT Sloan Management Review	Management	Customer needs	Conceptual	Conceptual
Verganti, 2008	Design, Meanings, and Radical Innovation: A Metamodel and a Research Agenda	Journal of Product Innovation Management	Innovation	Customer needs	Conceptual	Conceptual
Baregheh, Rowley and Sambrook, 2009	Towards a Multidisciplinary Definition of Innovation	Management Decision	Management	Innovation	Conceptual	Literature review
Griffin et al., 2009	Voices from the field: How exceptional electronic industrial innovators innovate	Journal of Product Innovation Management	Innovation	Creativity	Empirical	Qualitative
Hentschel, 2009	Attribute-domain matrix: A reverse engineering method for innovation	Creativity and Innovation Management	Creativity	Design Theories	Conceptual	Conceptual
Jang et al., 2009	Design-oriented new product development	Research-Technology Management	Innovation	NPD	Empirical	Qualitative
Puccio and Grivas, 2009	Examining the relationship between personality traits and creativity styles	Creativity and Innovation Management	Creativity	Creativity	Empirical	Quantitative
Verganti, 2009	Design Driven innovation	BOOK: Harvard Business Press	Management	Innovation	Book	Book
Goffin, Lemke and Koners, 2010	Identifying Hidden Needs: Creating Breakthrough Products	BOOK: London: Palgrave Macmillan	Management	Customer needs	Book	Book
Goffin and Mitchell, 2010	Innovation Management: Strategy and Implementation Using the Pentathlon Framework	BOOK: London: Palgrave Macmillan	Management	Innovation	Book	Book
Brown and Katz, 2011	Change by design	Journal of Product Innovation Management	Innovation	Design Theories	Conceptual	Conceptual
Dorst, 2011	The core of 'design thinking' and its application	Design Studies	Design	Design Theories	Conceptual	Literature Review
Euchner and Henderson, 2011	The practice of innovation: Innovation as the management of constraints	Research-Technology Management	Innovation	Customer needs	Conceptual	Conceptual
Gorry and Westbrook, 2011	Can you hear me now? Learning from customer stories	Business Horizon	Management	Customer needs	Conceptual	Conceptual
Henderson, 2011	The value of customer insights	Marketing Research	Marketing	Insights	Conceptual	Conceptual
Hillebrand, Nijholt and Nijssen, 2011	Exploring CRM effectiveness: An institutional theory perspective	Journal of the Academy of Marketing Science	Marketing	Market Research	Empirical	Quantitative
IDEO, 2011	Human Centred Design Toolkit	BOOK: IDEO	Design	Design Theories	Book	Book
Rejeb, Boly and Guimaraes, 2011	Attractive quality for requirement assessment during the front-end of innovation	TQM Journal	Production/quality	Customer needs	Conceptual	Conceptual
Simonton, 2011	Creativity and discovery as blind variation: Campbell's (1960) BVSR model after the half-century mark.	Review of General Psychology	Psychology	Creativity	Conceptual	Conceptual
Ulrich, 2011	Design is everything?	Journal of Product Innovation Management	Innovation	Design Theories	Conceptual	Conceptual

Reference	Title	Publication/Journal	Journal Field	Focus Area	Article type	Research Method
Bharadwaj, Nevin and Wallman, 2012	Explicating hearing the voice of the customer as a manifestation of customer focus and assessing its consequences	Journal of Product Innovation Management	Innovation	Customer needs	Empirical	Quantitative
Cropley and Cropley, 2012	A psychological taxonomy of organizational innovation: Resolving the paradoxes	Creativity Research Journal	Creativity	Creativity	Conceptual	Literature review
Goffin, Varnes, van der Hoven, Koners, 2012	Beyond the voice of the customer: Ethnographic market research	Research-Technology Management	Innovation	Market Research	Conceptual	Qualitative
Kahn et al., 2012	An Examination of New Product Development Best Practice	Journal of Product Innovation Management	Innovation	Market Research	Empirical	Quantitative
Norman and Verganti, 2012	Incremental and radical innovation	Design Issues	Design	Innovation	Conceptual	Conceptual
Schirr, 2012	Flawed Tools: The Efficacy of Group Research Methods to Generate Customer Ideas	Journal of Product Innovation Management	Innovation	Market Research	Literature review	Literature review
Thomke and von Hippel, 2012	Customers as innovators: A new way to create value	Harvard Business Review	Management	Customer needs	Conceptual	Conceptual
Bohlmann et al., 2013	The interplay of customer and product innovation dynamics: An exploratory study	Journal of Product Innovation Management	Innovation	Customer needs	Empirical	Qualitative
Carlgren, 2013	Identifying latent needs: Towards a competence perspective on attractive quality creation	Total Quality Management & Business Excellence	Production/quality	Customer needs	Conceptual	Conceptual
Creusen, Hultink and Eling, 2013	Choice of consumer research methods in the front end of new product development	International Journal of Market Research	Marketing	Market Research	Empirical	Quantitative
Lee and Therriault, 2013	The cognitive underpinnings of creative thought: A latent variable analysis exploring the roles of intelligence and working memory in three creative thinking processes	Intelligence	Management	Creativity	Empirical	Quantitative
Lukas and Whitwell, 2013	Why Do Customers Get More Than They Need? How Organizational Culture Shapes Product Capability Decisions	Journal of Marketing	Marketing	Customer needs	Empirical	Quantitative
Norman, 2013	The design of everyday things: Revised and expanded edition	BOOK: Basic Books	Design	Design Theories	Book	Book
Witell, Lofgren and Dahlgaard, 2013	Theory of attractive quality and the Kano methodology – the past, the present, and the future	Total Quality Management & Business Excellence	Production/quality	NPD	Literature review	Literature review
Baxter, Goffin and Szwejczewski, 2014	The repertory grid technique as a customer insight method	Research-Technology Management	Innovation	Customer needs	Empirical	Qualitative
Cunningham and MacGregor, 2014	Productive and Re-productive Thinking in Solving Insight Problems	Journal of Creative Behaviour	Creativity	Creativity	Empirical	Quantitative
Harvey, 2014	Creative synthesis: Exploring the process of extraordinary group creativity	Academy of Management Review	Management	Creativity	Conceptual	Conceptual
Kounios and Beeman, 2014	The Cognitive Neuroscience of Insight	Annual Review of Psychology	Psychology	Insights	Literature review	Literature review

Reference	Title	Publication/Journal	Journal Field	Focus Area	Article type	Research Method
Laughlin, 2014	Opinion piece: Holistic customer insight as an engine of growth	Journal of Direct, Data and Digital Marketing Practice	Marketing	Insights	Conceptual	Conceptual
Liedtka, 2014	Innovative ways companies are using design thinking	Strategy & Leadership	Management	Design Theories	Conceptual	Conceptual
van den Ende, Frederiksen and Prencipe, 2014	The front end of innovation: Organizing search for ideas	Journal of Product Innovation Management	Innovation	Front-end	Conceptual	Conceptual
Wallas, 2014	The art of thought	BOOK: Solis Press	Psychology	Creativity	Book	Book
Zaltman, 2014	Are you mistaking facts for insights?	Journal of Advertising Research	Marketing	Insights	Conceptual	Conceptual
Liedtka, 2015	Perspective: Linking design thinking with innovation outcomes through cognitive bias reduction	Journal of Product Innovation Management	Innovation	Design Theories	Conceptual	Conceptual
Price, Wrigley and Straker, 2015	Not just what they want, but why they want it: Traditional market research to deep customer insights	Qualitative Market Research	Marketing	Customer needs	Empirical	Qualitative
Weisberg, 2015	Toward an integrated theory of insight in problem solving	Thinking and Reasoning	Psychology	Insights	Conceptual	Conceptual
Said et al., 2015	How organisations generate and use customer insight	Journal of Marketing Management	Marketing	Insights	Empirical	Qualitative
Ulrich and Eppinger, 2015	Product Design and Development	BOOK: McGraw-Hill Education	Management	NPD	Book	Book
Weigel and Goffin, 2015	Creating Innovation Capabilities	Research-Technology Management	Innovation	Customer needs	Empirical	Qualitative
Carlgren, Rauth and Elmquist 2016	Framing design thinking: The concept in idea and enactment	Creativity and Innovation Management	Creativity	Design Theories	Empirical	Qualitative
Frishammar et al., 2016	The front end of radical innovation: A case study of idea and concept development at Prime Group	Creativity and Innovation Management	Creativity	Front-end	Empirical	Qualitative
Hamilton, 2016	Consumer-based strategy: using multiple methods to generate consumer insights that inform strategy	Journal of the Academy of Marketing Science	Marketing	Insights	Conceptual	Conceptual
Price and Wrigley, 2016	Design and a Deep Customer Insight Approach to Innovation	Journal of International Consumer Marketing	Marketing	Insights	Empirical	Qualitative
Wieneke and Lehrer, 2016	Generating and exploiting customer insights from social media data	Electronic markets	Marketing	Insights	Empirical	Qualitative
Eling and Herstatt, 2017	Managing the Front End of Innovation—Less Fuzzy, Yet Still Not Fully Understood	Journal of Product Innovation Management	Innovation	Front-end	Conceptual	Literature Review
Frederiksen and Knudsen, 2017	From Creative Ideas to Innovation Performance: The Role of Assessment Criteria	Creativity and Innovation Management	Creativity	Creativity	Empirical	Quantitative
Sprugnoli et al., 2017	Neural correlates of Eureka moment	Intelligence	Management	Insights	Conceptual	Conceptual

A.3 SLR Customer Need Definition Papers

No.	Reference	Field	Article Type	Purpose/Question	Needs term	Definition
1	Holt, Geschka and Peterlongo (1984)	Management	Book	Presents a model for finding customer needs	Existing Needs	Explicit and can be easily articulated, the customer is consciously aware of these. Recognised discrepancy between existing and wanted situation.
					Future Needs	Do not exist at present but will materialise in the future. May come from the availability of new technologies, adjacent technologies, or possible cultural and environmental changes.
					Emotional Needs	Emotional needs are broken down into three values. Attentive values represent how the customer will be emotionally engaged by using the product, symbolic values refer to how the product affects the customer's self-image and status, the character value refers to how the customer reacts to the product's aesthetics.
					Rational Needs	Needs that meet the customer's functional and use requirements of the product – does the product fundamentally do the job it was purchased to do?
2	Hauser and Clausing (1998)	Management	Conceptual	Presents the usage of the house of quality process.	Customer attributes	Phrases in the customer's own words used to describe product and product characteristics.
3	Griffin and Hauser (1993)	Marketing	Empirical. Quantitative Interviews in US	1) How many customers need to be interviewed? 2) How many analysts need to read the transcripts? 3) How many customer needs do we miss? 4) Are focus groups or one-on-one interviews superior?	Voice of the customer	A description, in the customer's own words, of the benefit to be fulfilled by the product or service. Customer need is not a solution. Needs include basic needs, articulated needs, and exciting needs.

No.	Reference	Field	Article Type	Purpose/Question	Needs term	Definition
4	Goffin and Lemke (2004)	Management	Book	Presents a model for finding customer needs.	Hidden needs	Requirements that customers or users have but which they have not yet directly recognised. As these requirements rest on a sub-conscious level, users are unable to articulate them.
5	Matthing, Sanden and Edvardsson, (2004)	Marketing	Conceptual. Literature Review	Reviews the literature on customer involvement in innovation.	Latent needs	What customers really value or the products and services they need but have never experienced or would never think to request.
6	Rosenthal and Capper, (2006)	Innovation	Empirical. Qualitative Case Study in US with two firms	The article considers the implications of the physical and emotional context of product uses and explores the how and when this may be done during a critical early stage of the product innovation process.	Tacit Needs	Need that goes beyond the view of a product as a set of explicit performance features and functions and to consider the implications of the physical and emotional context of product use.
7	Bohlman (2013)	Innovation	Empirical. Qualitative Interview in US with 17 Managers	(1) the customer's perspective in terms of change in customer needs and preferences (2) the firm's perspective of how innovation strategies interact with customer dynamics.	Dynamic customer needs	Customers evaluate the want and benefits of a new product from the reference point of their experience with similar products. Their needs will change as time progresses, due to their expectations of the new product.
8	Ulwick and Bettencourt (2008)	Management	Conceptual	Introduces a set of timeless standards that define the purpose, structure, content, and format of a customer need statement.	Customer Need Statement	Reflects the customer's definition of value. Has universal acceptance. Is relevant now and in the future. Prompts a course of action. The statement's meaning must not be open to interpretation. The statement itself must not confound the way it or other statements are prioritised.

A.4 SLR Customer Insight Definition Papers

No .	Reference	Field	Article Type	Purpose/Question	Insight Definition
1	Kounios and Beeman (2014)	Psychology	Conceptual. Literature Review	A review of the cognitive neuroscience research.	A sudden comprehension, realisation, or problem solution that involves a reorganisation of the elements of a person's mental representation of a stimulus, situation, or event to yield a non-obvious or non-dominant interpretation.
2	Simonton (2001	Creativity	Conceptual. Literature Review	Presents a history of creativity research.	A process based on reconstructing the core of a problem, rethinking its basic assumptions, and originating a new and creative solution, a process usually occurring in an unexpected and unpredictable manner.
4	Zaltman (2014)	Marketing	Conceptual	Assesses the relationship between facts and insights.	A realisation, an idea that feels correct; it is a thought experienced as true at the moment it reaches awareness. An insight is not an interpretation of a fact, "a fact announces, 'I am' an insight answers the question 'so what?'".
5	Florin, Pratzel and Kropp (2007)	Marketing	Conceptual	Aims to explore how deep you must go, while revealing market-savvy ways to make your product or brand better serve the needs of your target consumer.	Explains the why, when, and how customers purchase and use the product.
6	Wieneke and Lehrer (2016)	Marketing	Empirical. Qualitative case study in Swiss and German firms	How can firms generate and exploit customer insights from social media data?	An in-depth and actionable knowledge of customer needs and underlying motivations.
7	Hillebrand, Nijholt and Nijssen (2011)	Marketing	Empirical. Quantitative Questionnaire	Under what circumstances CRM stands a better chance of succeeding?	An understanding of current customer needs, the reasons behind these needs, and how these change over time.

No .	Reference	Field	Article Type	Purpose/Question	Insight Definition
8	Wills (2005)	Marketing	Conceptual	Presents a model for the way that insight should be managed and communicated such that it can deliver its full potential.	A deep, embedded knowledge about the customers and the market around us that helps structure thinking and sound decision making.
9	Laughlin (2014	Marketing	Conceptual	The article considers the core components, both defining and technical, for a customer insight function.	A non-obvious understanding of your customers which, if acted upon, has the potential to change their behaviour for mutual benefit.
10	Smith, Wilson and Clark (2006)	Marketing	Conceptual	Presented a practical understanding of customer insight definition.	Knowledge about customers which meets the criteria of an organisational strength; that is, it is valuable, rare, and difficult to imitate and with which the organisation is aligned to make use of the context of the relevant situation.
11	Said *et al.* (2015)	Marketing	Empirical. Qualitative case study in UK	How manager generate and use customer insights.	Not just customer information: to generate a customer insight from and about a customer requires transformation.

Source: Author

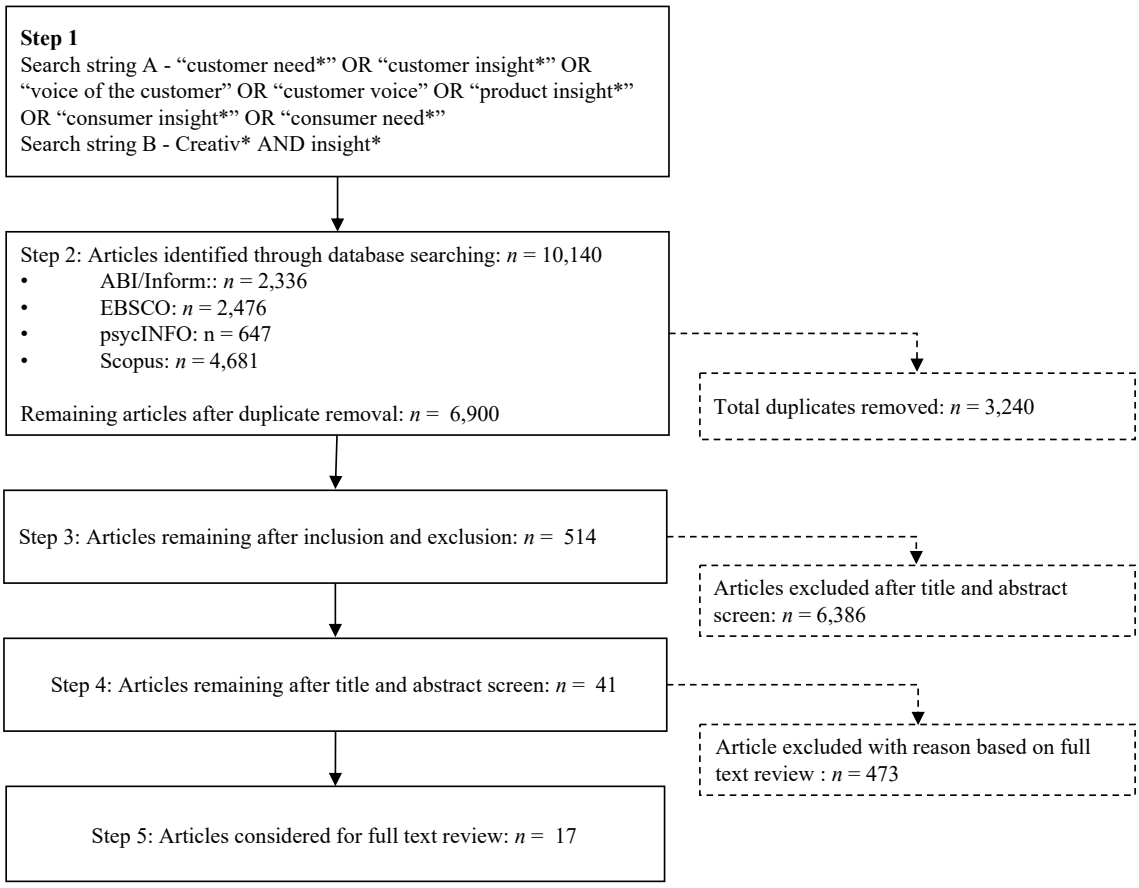
A.5 Evaluation of Case Study Research using CASET

No.	Publication	Theoretical foundation	Pilot study	Theoretical sampling	Triangulation	Review and validation of data	Transparency of data collection	Inter-coder agreement	Case presentation	Case interpretation	Reflecting on validity and reliability	Overall quality score (out of 10)
1	Wallendorf and Arnould (1991)	0	0	1	1	0	1	1	1	1	0	6
2	Arnould and Wallendorf (1994)	1	0	1	0	0	1	1	1	1	0	6
3	Amabile (1997)	0	0	1	1	0	1	0	1	1	0	5
4	Khurana and Rosenthal (1997)	0	0	1	1	0	1	1	1	1	0	6
5	Thompson (1997)	1	0	1	1	0	1	1	1	1	0	7
6	Khurana and Rosenthal (1998)	0	0	1	0	0	1	1	1	1	0	5
7	Durgee, O'Connor, and Veryzer (1998)	0	0	0	0	0	1	1	0	1	0	3
8	Hargadon and Bechky (2006)	1	0	1	1	1	1	1	1	1	1	9
9	Arnould and Price (2006)	0	0	1	0	0	0	1	1	1	0	4
10	Rosenthal and Capper (2006)	0	0	1	1	0	1	1	1	1	0	6
11	Griffin *et al.* (2009)	0	0	1	1	0	1	1	1	1	0	6
12	Jang *et al.* (2009)	0	0	0	0	0	1	1	1	1	0	4
13	Goffin *et al.* (2012)	0	0	0	1	0	1	1	1	1	0	5

No.	Publication	Theoretical foundation	Pilot study	Theoretical sampling	Triangulation	Review and validation of data	Transparency of data collection	Inter-coder agreement	Case presentation	Case interpretation	Reflecting on validity and reliability	Overall quality score (out of 10)
14	Bohlmann *et al.* (2013)	0	0	1	1	0	1	1	1	1	1	7
15	Baxter, Goffin and Szwejczewski (2014)	0	0	0	1	0	1	1	1	1	0	5
16	Price, Wrigley and Straker (2015)	0	0	1	1	0	1	1	1	1	0	6
17	Weigel and Goffin (2015)	0	0	1	1	0	1	1	1	1	0	6
18	Said *et al.* (2015)	1	0	1	1	0	1	1	1	1	1	8
19	Carlgren, Rauth and Elmquist (2016)	1	0	1	1	0	1	1	1	1	1	8
20	Frishammar *et al.* (2016)	1	0	1	1	0	1	1	1	1	1	8
21	Price and Wrigley (2016)	0	0	1	0	0	1	1	1	1	0	5
22	Wieneke and Lehrer (2016)	1	0	0	1	0	1	1	1	1	0	6

Source: Author

A.6 Revised SLR 2019 to 2023 Summary Flow

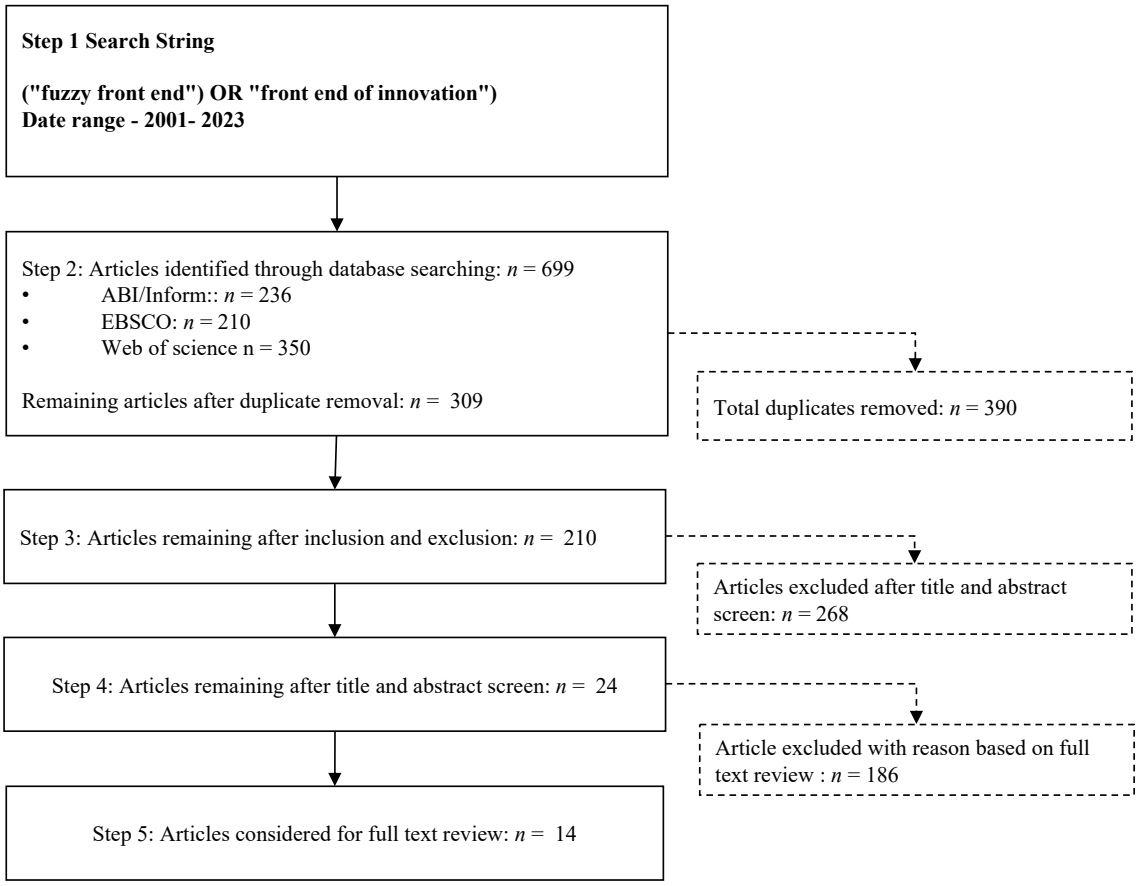


A.7 Revised SLR 2019 to 2023: Articles for Full Text Review

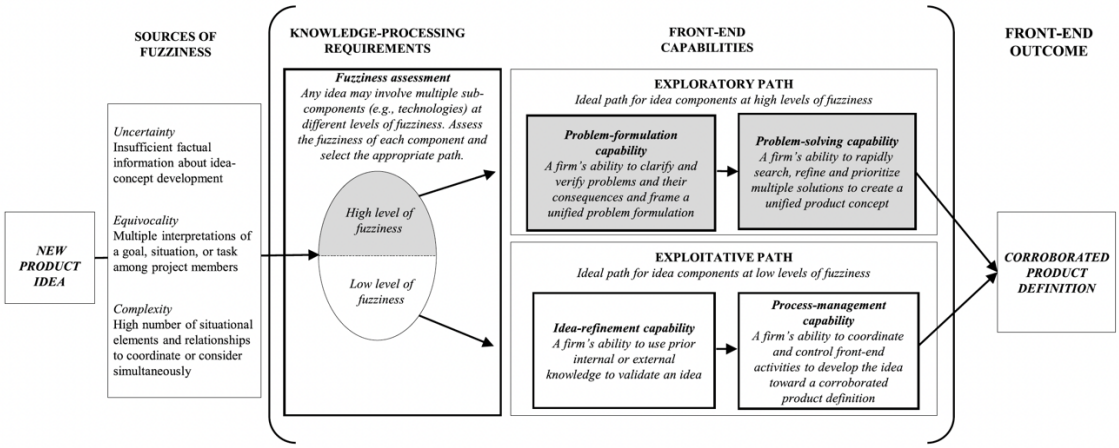
Author	Title	Year	Publication/Journal	Journal Field
Haber N., Fargnoli M.	Prioritizing customer requirements in a product-service system (PSS) context	2019	TQM Journal	Management
Timoshenko, A., Hauser J. R.	Identifying Customer Needs from User-Generated Content	2019	Marketing Science	Marketing
Veselaj, S., Torfason, M. T.	When To Call the Customer? Timing Of Customer Involvement in the Development of New Products and Services	2019	International Journal of Innovation Management	Innovation
Walia, C	A dynamic definition of creativity	2019	Creativity Research Journal	Creativity
Frank, L., Poll, R., Roeglinger, M., Lea, R.	Design heuristics for customer-centric business processes	2020	Business Process Management Journal	Management
Green, W.; Cluley, R.; Gasparin, M.	Mobile Market Research Applications as a New Voice of Customer Method	2020	Research Technology Management	Marketing
Knight, E.; Daymond, J.; Paroutis, So.	Design-Led Strategy: How To Bring Design Thinking Into The Art of Strategic Management	2020	California Management Review	Innovation
Verganti R., Vendraminelli L., Iansiti M.	Innovation and Design in the Age of Artificial Intelligence	2020	Journal of Product Innovation Management	Innovation
Auernhammer J., Roth B.	The origin and evolution of Stanford University's design thinking: From product design to design thinking in innovation management	2021	Journal of Product Innovation Management	Innovation
Deichmann D., Moser C., van den Ende J.	Talk, talk, talk: exploring idea conversations and the micro-level foundations of knowledge sharing for innovation	2021	Innovation: Organization and Management	Marketing
Randhawa K., Nikolova N., Ahuja S., Schweitzer J.	Design thinking implementation for innovation: An organization's journey to ambidexterity	2021	Journal of Product Innovation Management	Innovation
Wyrtki, K., Röglinger, M., Rosemann, M.	Opportunity-led ideation: How to convert corporate opportunities into innovative ideas	2021	Creativity and Innovation Management	Innovation
Jach P., Antony J., Thomson S.P., Cudney B., Furterer S.,	Voice of the customer as a tool for service quality analysis in public transport	2022	TQM Journal	Management
Ozdemir, M.; Verlinden, J.; Cascini, G.	Design methodology for mass personalisation enabled by digital manufacturing	2022	Design Science	Innovation

A.8 Front-End of Innovation Theory literature

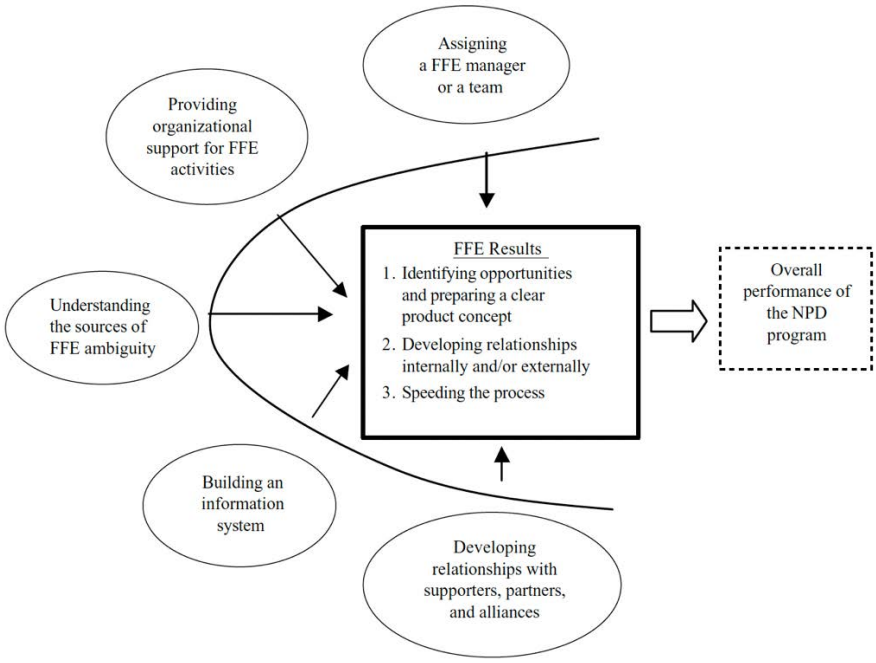
Search results



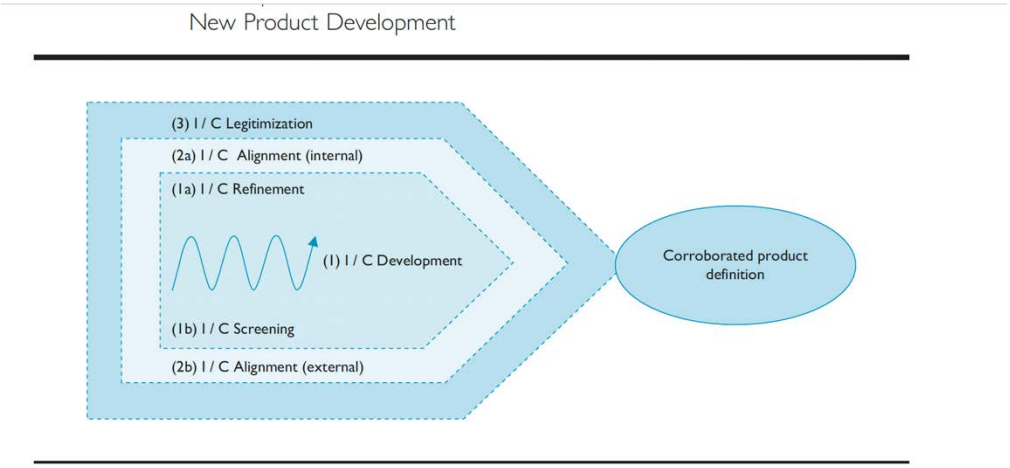
Frameworks



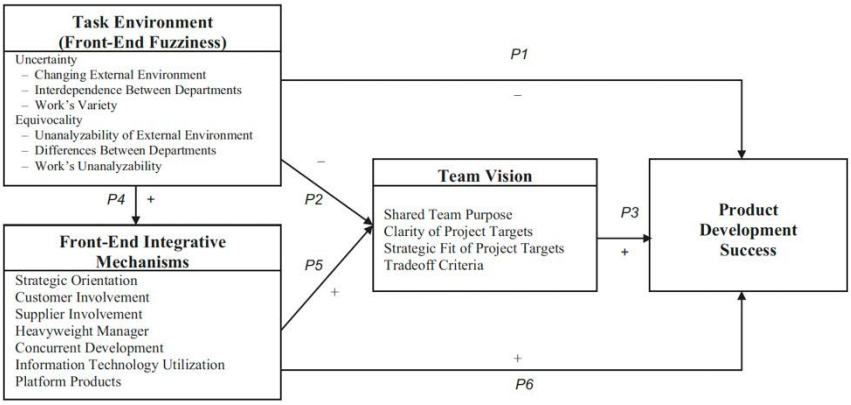
Adapted from Gama *et al.,* 2022.



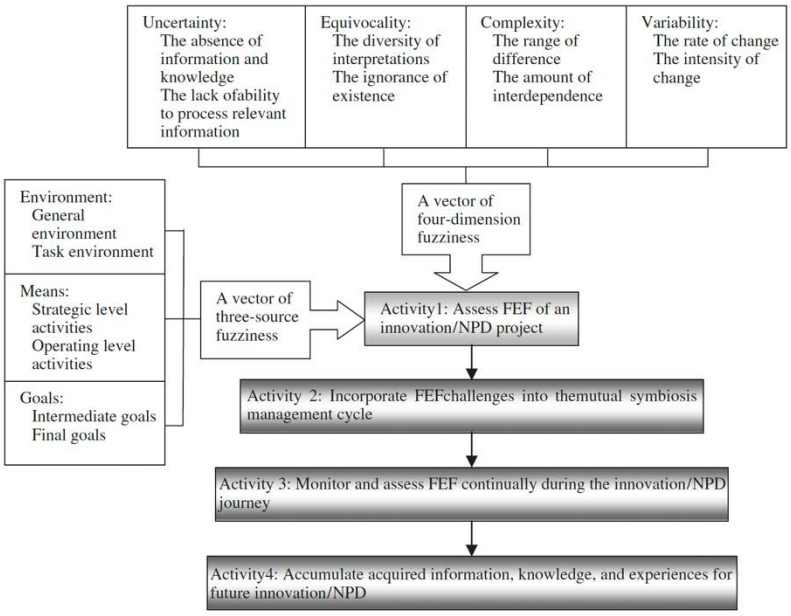
Adapted from Kim and Wilemon, 2002.



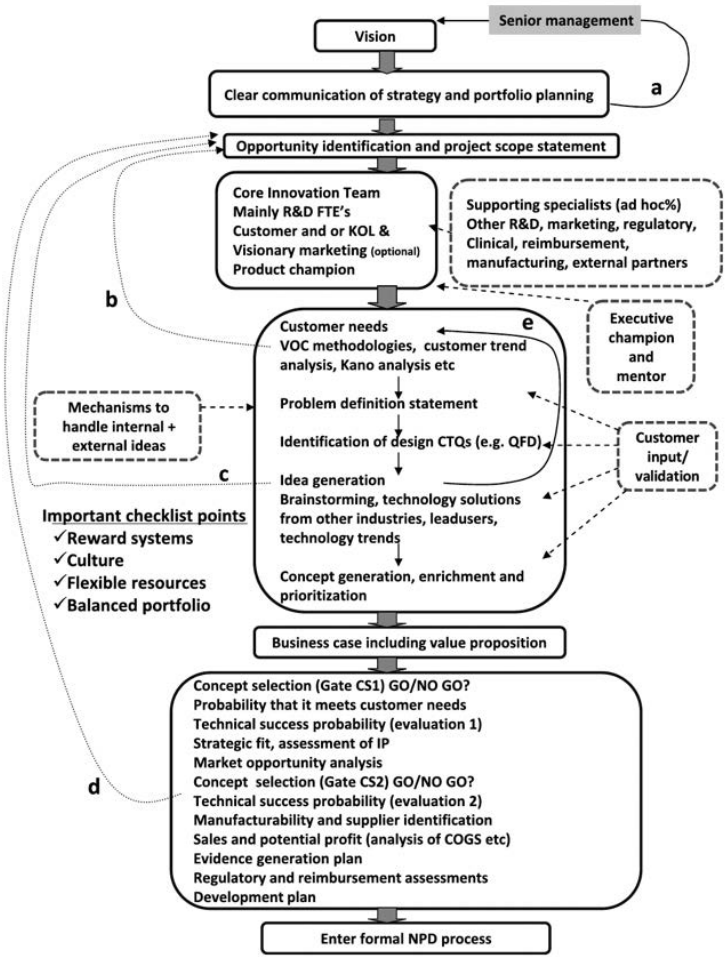
Adapted from Florén and Frishammar, 2012.



Adapted from Zhang, Cao and Doll, 2019.



Adapted from Chang, Chen and Wey, 2007.



Adapted from Trotter, 2011.

Appendix B – Research Methodology

B.1 SLR Provision Coding List

No.	SLR Provision Code	Holt, Geschka and Peterlongo (1984)	Hauser and Clausing (1988)	Griffin and Hauser (1993)	Goffin and Lemke (2004)	Matthing, Sanden and Edvardsson	Rosenthal and Capper (2006)	Bohlman et al. (2013)	Ulwick and Bettencourt (2008)	Kounios and Beeman (2014)	Simonton (2001)	Zaltman (2014)	Florin, Pratzel and Kropp (2007)	Wieneke and Lehrer (2016)	Hillebrand, Nijholt and Nijssen	Wills (2005)	Laughlin (2014	Smith, Wilson and Clark (2006)	Said et al. (2015)
1	VOC or Voice of the Customer		X	X	X		X		X						X				
2	Own words		X	X															
3	Benefits and values		X	X															X
4	Technology solution and technical language	X		X		X		X									X		
5	Identifying needs	X		X					X									X	
6	Identifying and generating insights									X		X	X	X		X	X	X	X
7	Listening to customer				X		X												
8	Unarticulated, tacit, latent, unconscious				X							X						X	
9	Customer involvement	X	X			X													
10	Market research				X	X							X			X		X	
11	Ethnography and observation				X		X												
12	Design – user, human centred, empathic, thinking						X												
13	Radical, incremental innovation							X											
14	Market orientation							X							X				
15	Dynamic and evolving needs							X											
16	Creativity and imaginative thinking									X	X	X							
1	Gestalt										X								

No.	SLR Provision Code	Holt, Geschka and Peterlongo (1984)	Hauser and Clausing (1988)	Griffin and Hauser (1993)	Goffin and Lemke (2004)	Matthing, Sanden and Edvardsson	Rosenthal and Capper (2006)	Bohlman et al. (2013)	Ulwick and Bettencourt (2008)	Kounios and Beeman (2014)	Simonton (2001)	Zaltman (2014)	Florin, Pratzel and Kropp (2007)	Wieneke and Lehrer (2016)	Hillebrand, Nijholt and Nijssen	Wills (2005)	Laughlin (2014	Smith, Wilson and Clark (2006)	Said et al. (2015)
7																			
18	Deep understanding of customers underlying motivations						X					X	X	X					X
19	Transforming data into meaningful knowledge													X				X	

B.2 Sensemaking Provision Coding List

Sensemaking Stigliani and Ravasi (2012)	Sensemaking Code	Page Number from Paper
Main theme		
	Ambiguity	1234
	Back and forward sensemaking - individual to group	1233
	Collective sensemaking	1232
	Future oriented	1232
	Gap between reality and expectations	1233
	Individual sensemaking	1232
	Prospective	1251
	Retrospective reflection	1233
	Sensemaking stopping - feeling the new order	1246
Noticing and bracketing		
	Cues and triggers	1243
	Immersion in the task	1243
	Flux of experience	1243
	Provisional interpretations	1243
Articulating		
	Imbued with meaning	1245
	Lists of features	1244
	Material practice	1244
	Metaphors	1244
	Product and prototypes	1233
Elaborating		
	Brain dumping	1247
	Capturing ideas	1246
	Connecting brains	1248
	Elaborating	1250
	Integration of understanding	1245
	Iterations	1247
	New understanding	1245
	Organising thoughts	1247
	Visualisation	1245
Influnce		
	Interpretation - exchange, combine and construct	1248
	Persuade clients and customers	1248

B.3 Retrospective Case Study Interview Guide

Interview Guide – retrospective case study

Section 1 - Preamble	
Before interview begins	Request permission to record interview
Introduce myself	Stuart Grant, PhD research at Cranfield University SOM Researching the process for discovering customer insights
Explain anonymity/confidentiality of research	No company information will be shared or published. Only the process/story of the insight discovery will become part of the research. Any specific insight that you talk about will not be discussed in the research. The interview will be anonymised
Explain interview process	This interview will - Firstly, capture your demographics. - Secondly is split into 2 sections o Generally, discuss the definitions of customer needs and insights - Explore the specific project and the discovery of needs and insights

Section 2 - Participant Demographics
Name
Title & position
Describe your role in the company
Year in the current company
Experience in product innovation & R&D

Section 3 – Introduce Customer needs and insights
What do you understand by a customer need and have you heard of the term customer needs? *Do you use a different term?*
What do you understand by a customer insight and have you heard of the term customer Insight? *Do you use a different term?*
Describe the definition of a customer need and customer insight to the participant. (use PowerPoint)
What do you think of these definitions of needs and insights?
In your opinion, how do these terms relate to each other?
Answer any follow-up question

Section 4 – Critical incident questions
Let us now start to talk about the specific project xxxxx
Can you describe a time where a customer insight was discovered on a recent innovation project?
Can you describe the process you used?
What was the insight?
Who else was involved? How did they contribute?
Follow-up prompts if not already discussed: *When did the insights occur?* *How did the insight emerge?* *What led you to the insight discovery?* *Where did this lead?* *What was your project?* *In your opinion how innovative was the project?*

Section 5 – Closing	
Do you have anything more to say?	
In your opinion, do you think/feel we discussed the main points?	

B.4 Longitudinal Case Study Interview Guide – 1st Interview

Interview Guide for the Initial first interview – longitudinal case study

Section 1 - Preamble	
Before interview begins	Request permission to record interview
Introduce myself	Stuart Grant, PhD research at Cranfield University SOM Researching the process for discovering customer insights
Explain anonymity/confidentiality of research	No company information will be shared or published. Only the process/story of the insight discovery will become part of the research. Any specific insight that you talk about will not be discussed in the research. The interview will be anonymised
Explain interview process	This interview will be split into three sections - Firstly, capture your demographics. - Secondly, discuss the definitions of customer needs and insights - Finally, explore the specific project and the discovery of needs and insights
Longitudinal process	I would like to check-in with you at certain times for interviews to understand your journey through the front end with the project. I would estimate this would be every three months for the next ten months, so about two additional interviews that would last about 30 minutes.

Section 2 - Participant Demographics
Name
Title & position
Describe your role in the company
Years in the current company
Experience in product innovation & R&D

Section 3 – Introduce Customer needs and insights
What do you understand by a customer need and have you heard of the term customer needs? *Do you use a different term?* What do you understand by a customer insight and have you heard of the term customer Insight? *Do you use a different term?*
In your opinion, how do these terms relate to each other?

Section 4 – Critical incident questions **Let us now start to talk about the specific project**
Can you describe a time where a customer insight was discovered on a recent innovation project? Can you describe the process you used? What was the insight? Who else was involved? How did they contribute? What have you done so far in the front end? What is/are your next steps? When engaging a customer what are you asking for or looking for? What would you like to do? *Follow-up prompts if not already discussed:* *When did the insights occur?* *How did the insight emerge?* *What led you to the insight discovery?* *Where did this lead?* *What was your project?* *In your opinion how innovative was the project?*

Section 5 – Closing	
Do you have anything more to say?	
Share any relevant documents	
Follow-up – when next interview?	

B.5 Longitudinal Case Study Interview Guide – 2nd and 3rd Interviews

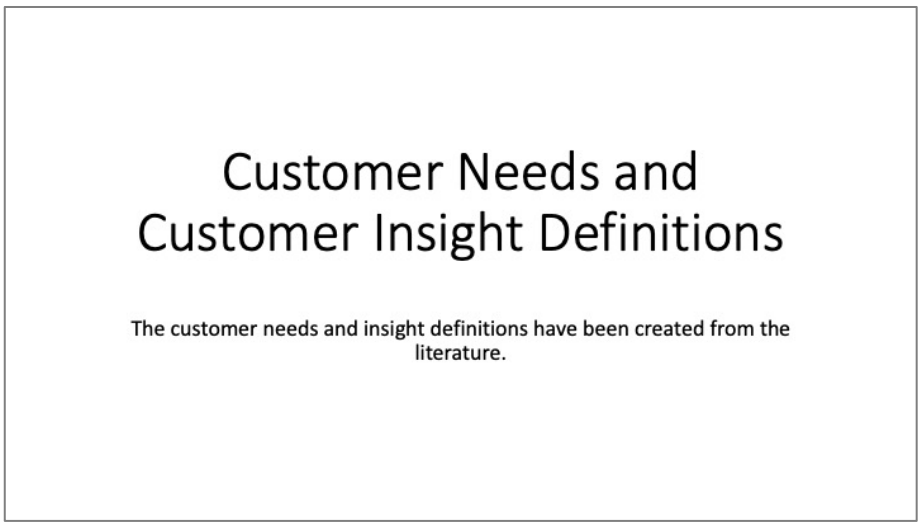
Interview Guide for the Second and Third interviews – longitudinal case study

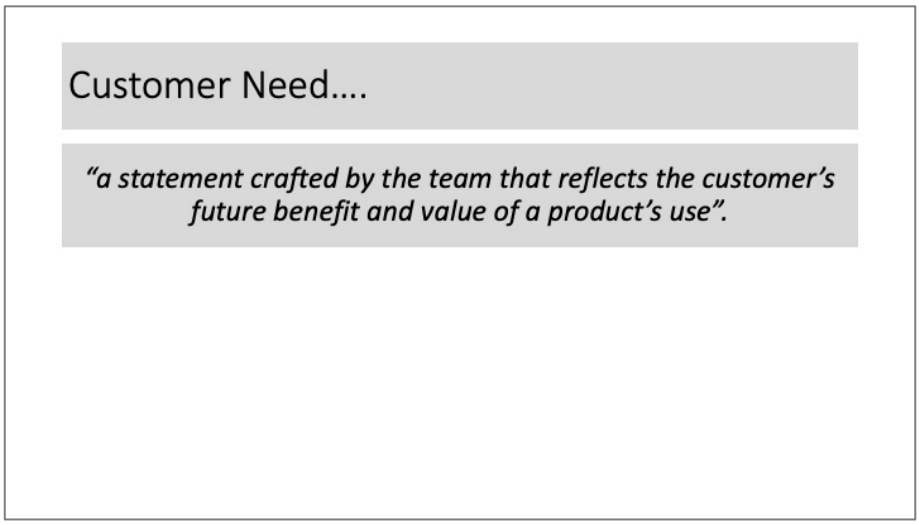
Section 1 - Preamble	
Before interview begins	Request permission to record interview
Introduce myself	Stuart Grant, PhD research at Cranfield University SOM Researching the process for discovering customer insights
Explain anonymity/confidentiality of research	No company information will be shared or published. Only the process/story of the insight discovery will become part of the research. Any specific insight that you talk about will not be discussed in the research. The interview will be anonymised
Explain interview process	This interview is a follow-on from the first/second interview to understand if any new insights have been discovered and for you to tell the story of the insights' discovery

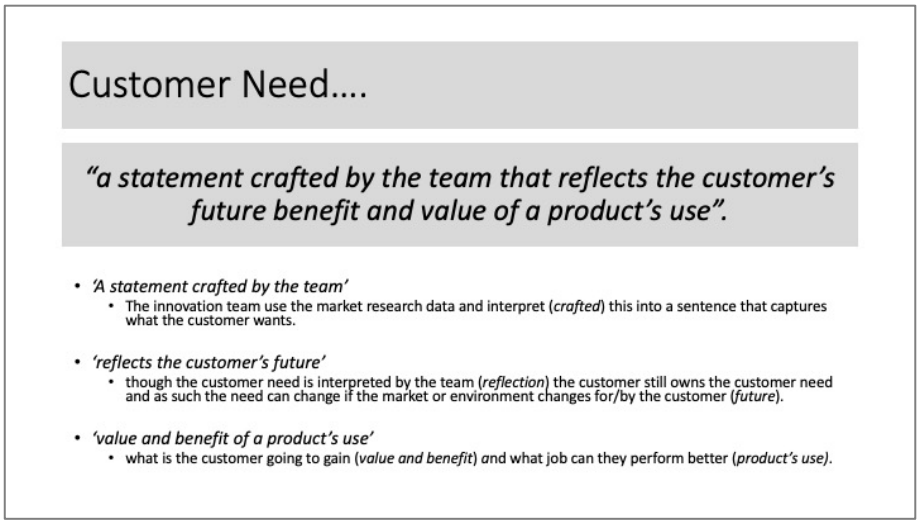
Section 2 – Critical incident questions
Can you tell the story where a customer insight was discovered on the project? • What was the insight? • When did the insights occur? • How did the insight emerge? • Where did this lead? • Who else was involved? How did they contribute? • How was the insight found? Can you describe the process you used? • What is/are your next steps? • When engaging customer what are you asking for or looking for? • What would you like to do?

Section 3 – Closing	
Do you have anything more to say?	
Share any relevant documents	
Follow-up – when next interview?	

B.6 Interview Definitions Presentation for 1st Interview







Customer Insight…

"an expression of deep knowledge about customers, that is an actionable non-obvious, creative solution".

Customer Insight…

"an expression of deep knowledge about customers, that is an actionable non-obvious, creative solution".

- *'an expression of deep knowledge'*
  - The innovation team gain a unique interpretation and comprehension of the customer
- *'actionable'*
  - is practical and implementable.
- *'non-obvious, creative solution'*
  - restructuring of the problem and recombination of data to create unexpected ideas.

Customer Need….

"a statement crafted by the team that reflects the customer's future benefit and value of a product's use".

Customer Insight…

"an expression of deep knowledge about customers, that is an actionable non-obvious, creative solution".

Appendix C – Data Supporting Case Study 1 Spark

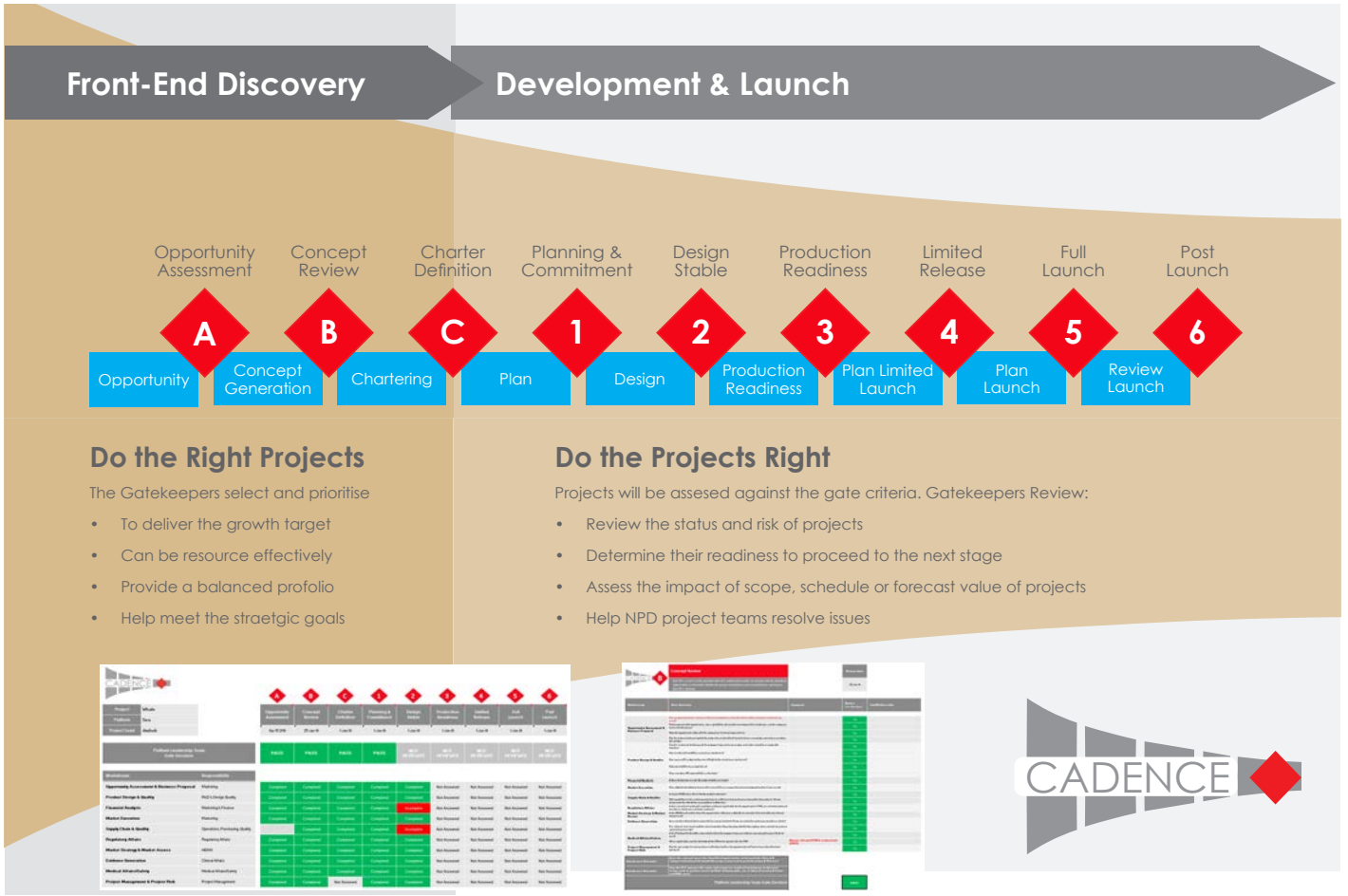
C.1 RQ2 Coding Structure - CS1 Spark

Code Name	References
RQ2 - CI process codes	162
Project Strategy	9
Initial problem understanding	3
Market driven unmet need	6
Understanding the Unmet Need	16
Problem statement process	7
Project innovativeness	4
Questioning the teams understanding of the needs	1
Technology solution and technical language	4
Engaging with Customers	39
Benefits and values	2
Communication with customers	3
Design discussions	13
Gathering customer inputs and opinions	5
Key People involved with the Insight	12
Listening to customer	4
Understanding the Customer Needs	41
Balancing needs with customers	3
Customer perspectives	4
Design - user, human-centred, empathic, thinking	2
Differing customer needs	2
Dynamic and evolving needs	7
Exploring the context	4
Finding the right question to ask	2
Hierarchy of needs	4
Iterating needs	4
Reason for needs	3
Unarticulated, tacit, latent, unconscious	6
Inability to articulate needs	4
Iterative Design and Development	26
Complexity of features	2
Customer reaction to prototypes	2
Design issues with the context of use	1
Design iterations and version releases	4

Code Name	References
Finding the MVP	3
Iteration of understanding	9
Prototype testing	5
Discovering Customer Insights	33
Describing the Insight	16
Finding insights	5
Lots of ahas	2
Realisation of a better design	5
Solution	5
Sensemaking Codes	110
Ambiguity	1
Articulating	3
Back and forward sensemaking - individual to group	16
Brain dumping	1
Capturing ideas	5
Collective sensemaking	10
Connecting brains	4
Cues and triggers	6
Elaborating	1
Future oriented	2
Gap between reality and expectations	4
Immersion in the task	2
Individual sensemaking	2
Influence	3
Integration of understanding	5
Interpretation - exchange, combine and construct	2
Iterations	8
List of features	1
Material practice	5
New Understanding	10
Noticing and bracketing	7
Organising thoughts	2
Product and prototypes	7
Provisional interpretations	2
Sensemaking stopping - feeling the new order	1

Code Name	References
Blanks	0
Creativity and imaginative thinking	0
Customer involvement	0
Deep understanding of customers underlying motivations	0
Ethnography and observation	0
Gestalt	0
Imbued with meaning	0
Identifying and generating insights	0
Identifying needs	0
Market orientation	0
Market research	0
Own words	0
Radical, incremental innovation	0
Transforming data into meaningful knowledge	0
VOC	0

C.2 Cadence Process Overview - CS1 Spark



C.3 Cadence Gate A Questions



Cadence PPM Master Template v5

Opportunity Assessment Review

Gate A is an assessment of the opportunity and determination of whether the business should pursue this project/idea/concept. *Gate A is optional, but recommended.*

Workstream	Planisware Gate Question	Tool/Deliverable
Opportunity Assessment & Business Proposal	Does the opportunity align with the companies' strategic imperatives?	Strategic assessment
	Has an attractive market opportunity been identified?	Opportunity assessment
	Is China a target market?	
	Is there a clear understanding of the current and future market opportunities, risks & uncertainties?	
Product Design & Quality	Is there a good understanding of the technical problems and space that need to be solved?	Initial technical assessment
Financial Analysis	Is there budget allocated to execute the project to the next gate?	R&D budget for project (R&D Finance)
	Will any third-party payments be required (e.g., royalties to HCPs/HCPEs, universities, other license fees, or fees to external development partners)?	
Market Execution	Have global stakeholders (internal and external) been engaged to understand opportunities and user needs?	Global stakeholder input
	If required by your business for this stage, has the Target Product Profile (TPP) been completed and approved? If not required by your business, answer this question as "N/A" (TPP generally starts at Gate C, but some businesses require it at Gates A/B).	Approved TPP
Regulatory Affairs	Is there an understanding of regulatory pathways applicable for the opportunity?	Initial Regulatory pathway consideration
HEMA	Is the HEMA lead satisfied that the opportunity addresses a globally meaningful clinical and/or non-clinical unmet need/burden of disease?	Burden of disease template
	Is there an understanding of the market access and reimbursement landscapes?	Market Access Assessment and Reimbursement Assessment
Pre-Clinical	Is there a good understanding of the current clinical environment with similar products?	
EGS	Has a Global Evidence Assessment been completed?	Global Evidence Assessment
Medical Affairs/Safety	Is the Medical Director satisfied that the opportunity represents a meaningful unmet medical need?	Initial Medical Affairs input
Project Management & Project Risk	Have the core project team members and budget to drive the opportunity to Concept Review (Gate B) been identified and assigned?	Resource and budget for next stage
Gatekeeper Question	Can the PLT approve the costs and resources required to progress in the next stage, such as market research (VOC, Ethnography, etc.) clinical testing and front-end R&D costs?	This question is not formally answered in Cadence PPM, but is provided as guidance for the Gatekeeper to consider at the Gate Review.
Gatekeeper Question	Does this opportunity have both clinical and commercial potential, align with our strategic direction, and in general is it worth pursuing?	This question is not formally answered in Cadence PPM, but is provided as guidance for the Gatekeeper to consider at the Gate Review.

C.4 Cadence Gate B Questions



Concept Review

Gate B is a review of the potential clinical and commercial benefits of concept with the identified opportunity, and to determine whether the project should proceed to prioritization and charter. *Gate B is optional, but recommended*.

Cadence PPM Master Template v5

Workstream	Planisware Gate Question	Tool/Deliverable
Opportunity Assessment & Business Proposal	Does the opportunity align with the companies' strategic imperatives?	Strategic assessment
	Has the primary business goal of the project been identified? (market share, expansion, sustaining, creation, disruption)	
	Have proposed product concept(s) and business model(s) been identified that will meet business and strategic needs?	Product Concepts/Business Models
	Is China a target market?	
	Having assessed the opportunity, core capabilities, the market and competitive landscape, can the company succeed in the space?	Opportunity & feasibility assessment
Product Design & Quality	Can the technical challenges of the proposed concept(s) be overcome and achieved within a reasonable timeline?	
	Has a general Intellectual Property (IP) landscape study been considered and conducted, as required?	IP assessment
	Will any third parties be engaged as part of the development process (e.g., HCPs, HCPEs, universities, or other external development partners)?	If HCPs or HCPEs will be involved, project needs to be presented to the Royalty Review Committee for approval.
Financial Analysis	Is there budget to execute the project to the next gate?	Clarify R&D budget for next stage
	Will any third-party payments be required (e.g., royalties to HCPs/HCPEs, universities, other license fees, or fees to external development partners)?	
Market Execution	Have global stakeholders (internal and external) been engaged to understand opportunities and user needs?	Global stakeholder input
	If required by your business for this stage, has the Target Product Profile (TPP) been completed and approved? If not required by your business, answer this question as "N/A" (TPP generally starts at Gate C, but some businesses require it at Gates A/B).	Approved TPP
Supply Chain & Quality	Is target Cost of Goods Sold (COGS) a key driver for the product concept(s)?	Initial COGS target established
	Will capabilities in the existing supply base be sufficient to manufacture/assemble this product? If not, please provide a list of the new suppliers and/or sites.	Initial supply base assessment
Regulatory Affairs	Is there an understanding of regulatory pathways applicable for the opportunity? If NO, are activities planned to achieve clarity on regulatory pathway?	Initial Regulatory pathway assessment
HEMA	Does the HEMA lead have an understanding of the product's value proposition as relevant for clinical and non-clinical audiences?	Value Proposition Map
	Is there an understanding of the market access and reimbursement requirements to support relevant global markets?	Market Access Strategy and Reimbursement Strategy
Pre-Clinical	Does biocompatibility/toxicology data exist for the patient contacting materials?	
	Have we identified if pre-market or postmarket clinical data is needed to support target markets?	
	Is in vivo feasibility data favorable?	
EGS	Has an Evidence Scan been completed, if applicable?	Evidence Scan
	Has the directly responsible individual (DRI) initiated discussions with the regions?	
Medical Affairs/Safety	Is the Medical Director satisfied that the proposed concept(s) address a meaningful unmet Medical need?	Initial Medical Affairs input
Project Management & Project Risk	Have the core project team members and budget to drive the opportunity to Charter (Gate C) been identified and assigned?	Resource and budget for next stage
Gatekeeper Question:	Can the PLT approve the costs and resources required to progress in the next stage, such as market research (VOC, Ethnography, etc.) clinical testing and front-end R&D costs?	This question is not formally answered in Cadence PPM, but is provided as guidance for the Gatekeeper to consider at the Gate Review.
Gatekeeper Question:	Does (Do) the concept(s) meet the identified opportunity and have both clinical and commercial potential? Should the project proceed to prioritization and Charter?	This question is not formally answered in Cadence PPM, but is provided as guidance for the Gatekeeper to consider at the Gate Review.

C.5 Extract from the Requirement Traceability Matrix - CS1 Spark

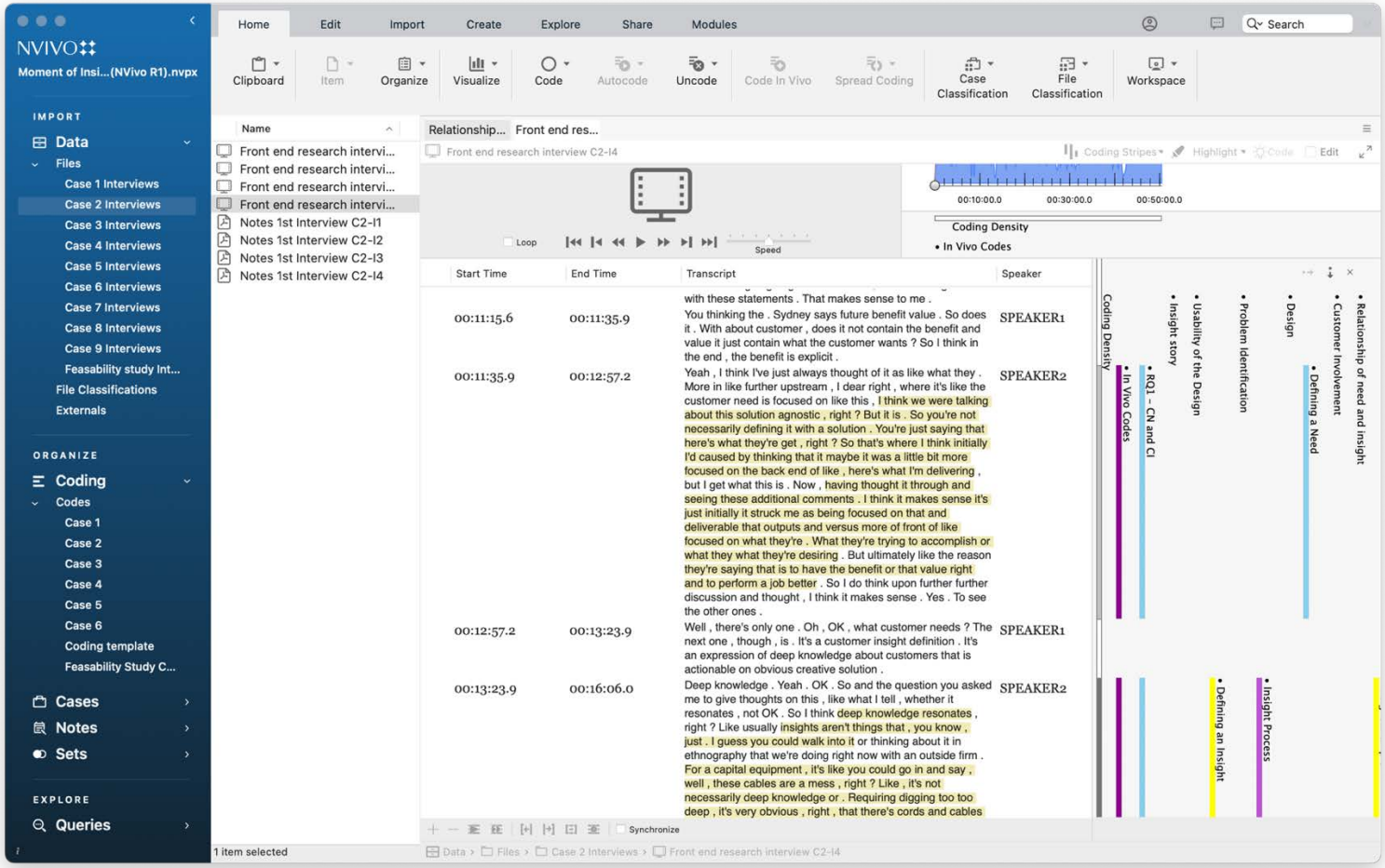
Requirements and Traceability Matrix

Project Name	[redacted]		
DHF and/or Project Number	[redacted]	**Doc No. and Rev**	[redacted]

Phase I Planning & Design Inputs			**Phase II Design Outputs**			**Phase III Design Verification**	**Phase IV Design Validation**
User Needs and Intended Uses	**Source of User Need and Intended Use**	**Design Inputs**	**Draft Design Outputs**	**Design Output Number**	**Critical to Quality (CTQ)?**	**Planned Design Verification Results/References**	**Planned Design Validation Results/References**
DYNH-990 User wants to be able to communicate required x-rays to the radiology department.	UNIU was identified through the completion of the task analysis activity.	DYHN-610 Project shall include a method for surgeon to request appropriate x-rays from the radiology department.	XXXX will include: 1. X-ray request form 2. X-ray acquisition protocol. *Reference needed*	1	Yes	Verification could consist of a review of outputs related to the process of requesting x-rays, to confirm that they exist and contain appropriate information.	Perform a hands on validation exercise in which the ability of surgeons to successfully complete the request method is evaluated. Perform a hands on validation exercise in which the ability of a radiographer or radiology technician to understand the request method is evaluated.
DYNH-989 Surgeon does not want to need a CT scan to use the technology	UNIU originates from the majority view of the Surgeon Design Team. While a minority of surgeons from the Australian and Chinese market had easy access to CT, the majority confirmed that a dependency on CT would be a significant barrier to market. Considering the various surgeon opinions and business needs, the PCT agreed the project should continue with the UNIU as written.	DYNH-842 XXXX technology shall only require x-rays in order to operate.	XXXX does not require a CT scan to operative. XXXX only requires either 3 (Standing lateral, Seated Lateral, Standing AP) or 4 x-rays (Standing lateral, Seated Lateral, Standing AP, Supine AP) depending on the selected workflow.	2	No	Verification to be completed via software development process.	Perform a hands on validation lab in which surgeons use the software in a representative environment, and confirm software meets the requirements without needing a CT.
DYNH-984 Surgeon wants to take the fewest number of additional x-rays possible to support the desired functionality, and wants the requirements of those x-rays to be as close as possible to routinely acquired x-rays	UNIU originates from the consensus view of the Surgeon Design Team. Considering the input from the surgeon design team the PCT agreed that the project should continue with the UNIU as written.	DYNH-841 XXXX technology shall only require a flexed seated lateral x-ray, a standing lateral x-ray and a standing AP Pelvis x-ray.	XXXX requires a minimum of 3 (Standing lateral, Seated Lateral, Standing AP) in order to function in the standing frame of reference workflow.	3	Yes	Verification to be completed via software development process.	Perform a hands on validation lab in which the surgeons confirm if the number of x-rays required is not excessive, and that the requirements for those x-rays are not excessive. Consider performing exercise with radiographers to determine if they are comfortable with acquiring require x-rays.

Appendix D – Data Supporting Case Study 2 Archway

D.1 RQ1 Example Coding of Transcript Interview - CS2 Archway



D.2 RQ1 Evidence of Understanding Customer Needs, Insights, and their Relationship - CS2 Archway

Theme	Representative Quotes
Understanding Customer Needs	*The market or environment changed, and the value proposition and the customer need therefore changed.* (C2-I1)
	A lot of times customers may not even know they need it. That's an interesting spin on it. So, here's the problem if you go out and ask potential customers, what are your needs? They say I'm satisfied with what I have, I don't have any needs for something. This is something we encounter quite a bit within product development.t (C2-I2).
	A belief or idea that's long held by them that sort of drives their actions in what they do and what they believe and perceive. A pain point or area of opportunity for an existing product or service. (C2-I3)
	It is something that they are looking for or something that they either know or don't know that they need. (C2-I4).
Understanding Customer Insights	*Their needs, their wants, their desires.* (C2-I1)
	It's feedback on current products or concepts on how well a customer's needs are met. A customer insight could also be an expression of deep knowledge about customers. That is something you don't want to do. (C2-I2)
	I generally like that non-obvious. It makes sense that it's not obvious because it took work to do it, took work and research, and it took thought to come up with a customer insight. (C2-I2)
	A creative solution is one that meets a lot of needs. It not only meets the customers. (C2-I2)
	It's like an emotional or functional idea or need that is driving behaviours and actions as it relates to a product. trying to sort of anticipate how a customer will respond to a future product or idea that gets at sort of underlying values and beliefs that will drive behaviour. (C2-I3)
	Little more preliminary. It's kind of the foundation of the user need. We're recognising this trend in the market. I think of it as being a little bit less defined or less. (C2-I3)
	I think of it as being a little bit less defined. We're recognising this trend in the market. I see it as like that spark of like there's something really to explore here or to investigate. (C2-I4)
Relationship of Customer Needs to Customer Insights	*I think I default to that the need is something that is indeed needed, whereas an insight might be a delight or might be some other things. So, I think there can be overlap, but I don't think that they are the same. we use the word need in my mind and this is something that has to be delivered, whereas an insight is something I can act on.* (C2-I1)
	I don't know if you can generate customer needs without generating customer insights, A lot of times we use customer insights to lead into a customer need. I think there are overlapping and lead, at least the insight can lead to the need. (C2-I2*)*
	The insight explains or provides the explanation and understanding of the need in a more actionable and sort of detailed way unique to a

	customer. they're closely linked but different. (C2-I3)
	Birthing the user need if you will. The user need coming from the inside. In a perfect world, an insight comes before that need. the insight matures into a more defined customer need. The insight that somebody is struggling with an area, right? or that there, that there's a gap in current offerings. I think you could definitely lead to multiple needs. (C2-I4)

D.3 RQ1 Participant's Response to the Customer Need Definition from the SLR - CS2 Archway

Customer Need Definition Broken down	Explanation	C2-I1	C2-I2	C2-I3	C2-I4	Supporting Quotes	Disconfirming Quotes
A statement crafted by the team	The innovation team analyse the market research data and interprets (crafted) this into a sentence/commentary that captures what the customer wants.	NM	+	NM	+	*It's not drafted by the customer that doesn't say you've actually went out and talked to customers. Crafted their statements that reflect what we're seeing here.* (C2-I2)	
Reflects the customer's future	Though the customer need is interpreted by the team (reflect), the customer still owns the customer need. As such, the need can change if the market or environment changes for/by the customer (future).	+	+	+	NM	*Reflects the customer's future. Well hopefully that's what it's about.* (C2-I2)	
Benefit from and value of a product's use	What will the customer gain (value and benefit), and the job they can perform better (product's use)	NM	+	-	+	*I like the word job, we use that a word a lot, particularly when it comes to products.* (C2-I2)	*Benefit comes from the need that's not the same encapsulated in the same. but they're related and they have to be related and they are linked but they're different.* (C2-I3)

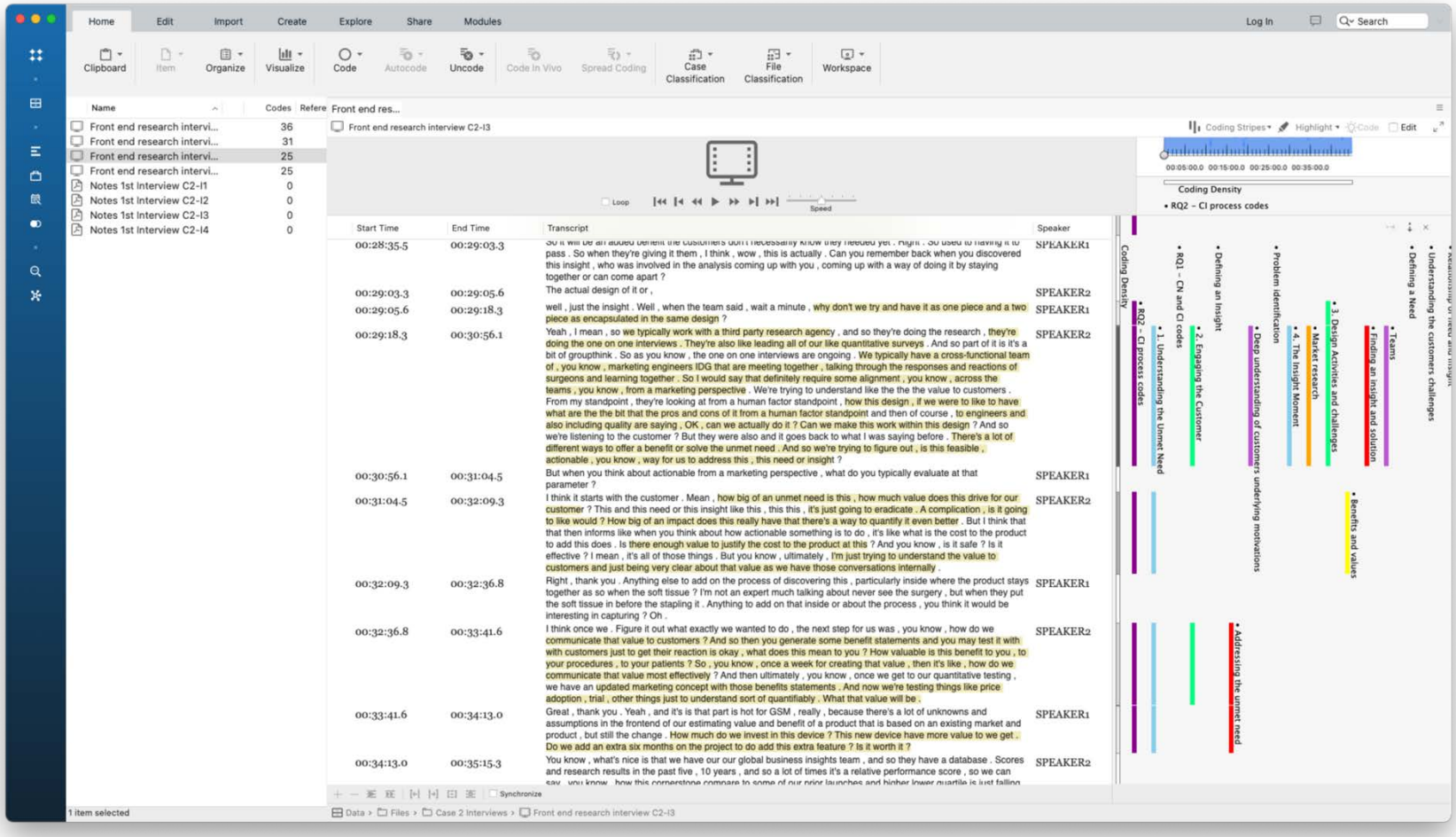
D.4 RQ1 Participant's Response to the Customer Insight Definition from the SLR - CS2 Archway

Customer Insight Definition Broken down	Explanations	C2-I1	C2-I2	C2-I3	C2-I4	Supporting Quotes	Disconfirming Quotes
Expression of deep knowledge	The innovation team gain a unique interpretation and comprehension of the customer needs and market research data	+	+	+	+	*The deep knowledge about the customer's right to me, that's what an insight is.* (C2-I1)	
Actionable	Is practical and implementable	+	NM	+	+	*It should be actionable, so I agree with that.* (C2-I4)	
Non-obvious, creative	Restructuring the problem and recombining data to create unexpected ideas	+	+	+	+	*Every creative solution can point back to some customer insights somewhere where somebody was like, oh, wouldn't it be great if we really have a problem here.* (C2-I4)	*I don't know if it's always not obvious. It may be obvious I don't know, if not obvious, is a limiter for what a customer insight is.* (C2-I4)
Solution		-	-	-	-		*You know that it's possible to solve but the insight statement in itself isn't always the solution.* (C2-I3)

D.5 RQ1 Participant's Response to the Relationship Between Customer Needs and Customer Insights - CS2 Archway

Case Participant	Relationship	Sequence	Other Relationship	Representative Quotes by Participant
C2-I1	Overlap	Not mentioned	Need – delivered. Insight – act on	*I think there can be overlap, but I don't think that they are the same.* *A need in my mind and is something that has to be delivered, whereas an inside is something I can act on.*
C2-I2	Overlap	Insight to need	Reciprocal	*I think they overlap big time.* *A lot of times we use customer insights to lead into a customer need.* *I don't know if you can generate customer needs without generating customer insights.*
C2-I3	Not mentioned	Insight to Need	NA	*Needs statement like they had this need because of these three insights that we gathered.*
C2-I4	Overlap	Insight to Need		*I think there is some overlap. Where the customer insight becomes that more defined customer need.* The insight matures into a more defined customer need. *In a perfect world, an insight comes before that need.*

D.6 RQ2 Example Coding of Transcript Interview - CS2 Archway



D.7 RQ2 Analysis: Second and First-order coding for the Insight Moment Process - CS2 Archway

Second-Order Codes	First-Order Codes	Representative Quotes	Case Participant
Project Strategy	Problem identification	*I've now got an assistant who's either handling the tissue or handling the device, which the Docs see as a loss of control, depending upon how comfortable they are with their surgical staff and how often their surgical staff changes.*	C2-I1
	Teams	*We typically have a cross-functional team of marketing engineers, IDHF that are meeting together, talking through the responses and reactions of surgeons, and learning together.*	C2-I3
Understanding the Unmet Need	Addressing the unmet need	*What they told us about that staple line was probably the biggest insight. They said that when there are leaks, leaks are complications. Patient populations are becoming increasingly challenging. There's a lot of co-morbidities and so there's a higher incidence of surgical complications.*	C2-I3
	Benefits and values	*The benefits of the stapler with a smaller footprint, less tissue damage, the haemostasis performance. So that really caused us to dig in and try to understand where the value lies.*	C2-I1
	Customer feedback	*It's not something that that they can address in the surgical room with something they've got handy. A leak is something they may have to reopen somebody for and that worries them much more.*	C2-I1
	Deep understanding of customer's underlying motivations	*Start to understand some of those insights around, like why they're doing this and why they're taking a certain step, if we give you a stronger or improved staple line integrity, then potentially you wouldn't have to take these additional steps in your procedure.*	C2-I3
	Ethnography and observation	*We knew we wanted to look at ASL surgery, but we're trying to be unbiased as far as what aspects of that just keep our eyes open for any needs and opportunities within instrumentation or procedure. we started going out and talking early on, cornerstone in the measure phase.*	C2-I4
	Existing design issues	*It's got some major usability - it falls apart. So, when you're putting this together, it takes four sets of hands to use this. You need two sets of hands and an assistant to hold the tissue, and it takes the surgeon two hands.*	C2-I2
Engaging with Customers	Asking question to customer	*It's what questions you ask and how you ask them and having the right people with the appropriate background to be able to ask those questions is really critical for us getting the right answers.*	C2-I1

Second-Order Codes	First-Order Codes	Representative Quotes	Case Participant
	Communication value	*Communicate that value to customers? And so, then you generate some benefit statements, and you may test it with customers just to get their reaction: What does this mean to you? How valuable is this benefit to you, to your procedures, to your patients?*	C2-I3
	Customer involvement	*Marketing group was able to they were able to go out and pick out surgeons.*	C2-I4
	Listening to customer	*You get different answers in different regions, which I find interesting. But they're solving different problems. So, I learned a lot about how you ask the question is as important as the questions you ask.*	C2-I1
	Market research	*We will do qualitative research, like one-on-one interviews with surgeons. And then we'll also do larger quant studies. And through that process, the customer tells us what their unmet need is. Through the market research process, you're trying to fine tune not only looking inwardly but also outwardly like what's going to be most meaningful to the customer.*	C2-I3
	Unarticulated, tacit, latent, unconscious	*There's the problem if you go out and ask potential customers, what are your needs? They say I'm satisfied with what I have, I don't have any needs.*	C2-I2
	Understanding the customers challenges	*We realised that when they went to place the device on tissue because the two halves are not connected or locked together, it sometimes would fall apart unexpectedly.*	C2-I3
	VOC	*Like a VOC, you ask surgeons, you ask patients about certain ideas you have for that patient wearable we had some initial VOC. They were conducted by the IDHF team.*	
Iterative Design and Development	Creating the design plan	*The design plan is the overarching document from a standpoint that outlines the overall project, the goals, the assumptions, the deliverables, and the opening statement.*	C2-I2
	Current design issues	*Lockout built in, so that if the knife is deployed, you can't open the device and expose yourself to the knife. The knife has to be retracted all the way back into the handle. But what happens if either the doctor not knowing or understanding how the device works or he gets himself into a situation where he's cut on something he shouldn't, and now it's stuck.*	C2-I1
	Customer experience	*The reason why we did this was for manufacturing and cost and also to the bigger thing to me is to make sure we have a consistent customer experience So when you build that curve in and it's consistent, it never changes.*	C2-I2

Second-Order Codes	First-Order Codes	Representative Quotes	Case Participant
	Design challenge	*That level of performance. But now the footprint of my device has to grow because I've got to fit another staple in, and I know mechanically forming with my hands three rows of staples versus to knowing my force to fire will go up. These are the trade-offs we need to understand from the customers, right?*	C2-I
	Design performance	*We actually have requirements on our product requirements workbook that we measure this pull apart force at a certain distance. So, at a certain moment arm and there's a minimum and maximum.*	C2-I2
	Design phase	*So, measures about the customer needs analysis phase are about figuring out what your architecture is going to be and then the next phase's detailed design.*	C2-I2
	Incremental design changes	*We've gotten rid of the nuisance failures that the doctors have learned to compensate for but not prevented them from doing that.*	C2-I1
	Innovation type	*Really transforming and how surgery is done, it's improving clinical outcomes because, we have a better staple line and it's making the surgeons life a little bit easier.*	C2-I2
	Needs reuse	*Sometimes we copy and paste our user needs from other projects or similar platforms, we have these general user needs around cleaning and sterilisation or packaging, packaging, sustainability, etc.*	C2-I4
	Prototype fidelity	*I think sometimes we think we've got to have a fully fleshed out solution, which we don't have to do, but we do have to have it fleshed out to a level where there's the willing suspension of disbelief on the behalf of the surgeon. He can see how this is going to work: this is what I would like about it, and this is what would worry me about it.*	C2-I1
	Balancing needs	*Simplified designs, this device has to be used in gastric procedures and thoracic procedures and in small bowel resections. It has to satisfy all those needs so that's the challenge.*	C2-I2
	Usability of the design	*From a usability standpoint was the size of the firing paddle right. So, we did a round of internal testing in our preclinical group, a consulting surgeon, and a surgeon from our medical affairs safety group. And one of the things that came up a couple of times in that was this paddle is so small, If I have to apply a lot of force and I'm pushing really hard on this, I want something that can actually grip.*	C2-I4

Second-Order Codes	First-Order Codes	Representative Quotes	Case Participant
Discovering Customer Insights	Creativity and imaginative thinking	*That's kind of where it led into this idea of no one had ever done anything like this on a linear cutter, we have a unique, proprietary design. It's very easy to snap on even to him. I can just snap it together. It'll stay there. It won't come apart, so I can take it apart through a pinch grip.*	C2-I1
	Finding an insight and solution	*The design is meant to support one hand placement on tissue. So now with a single hand, they can place the device on tissue and then have a free hand to actually manage the tissue itself as they're placing the device.*	C2-I3
	Identifying and generating insights	*Some of the insights, amount of angst that he might have will depend not only on the tissue he's doing, the surgery he's in, but also the staff that he has to support him and his comfort level with them. Yeah, that's not necessarily a need, that's an insight.*	C2-I1
	Product benefit claims	*We have demonstrated with our device that it has statistically significant leak performance and we believe we can use that in our claims instead of the haemostasis performance.*	C2-I3
	Product solution	*it's incredibly elegant and simple, and it's cheap and it's reliable. And I mean, it's really easy to manufacture. It's easy to put it together again.*	C2-I2

D.8 RQ2 Data Structure - CS2 Archway

Code Name	References
RQ2 - CI process codes	188
Project Strategy	20
Problem Identification	17
Teams	3
Understanding the Unmet Need	42
Addressing the unmet need	13
Benefits and values	10
Customer feedback	1
Deep understanding of customers underlying motivations	8
Ethnography and observation	9
Existing design issues	1
Problem identification	17
Teams	3
Engaging with Customers	36
Asking the customer questions	3
Communicating value	1
Customer involvement	6
Listening to customer	8
Market research	11
Unarticulated, tacit, latent, unconscious	4
Understanding the customer’s challenges	3
Iterative Design and Development	55
Balancing needs	3
Creating the design plan	1
Current design issues	2
Customer experience	3
Design	9
Design challenge	8
Design performance	8
Design phase	4
Incremental design changes	3
Innovation type	7
Needs reuse	1

Code Name	References
Prototype fidelity	1
Usability of the design	5
Discovering Customer Insights	35
Creativity and imaginative thinking	2
Finding an insight and solution	12
Identifying and generating insights	14
Product benefit claims	2
Product solution	5
Blanks	0
Design - user, human-centred, empathic, thinking	0
Gestalt	0
Market orientation	0
Own words	0
Radical, incremental innovation	0
Technology solution and technical language	0
Transforming data into meaningful knowledge	0
VOC	0

D.9 RQ2 Practices and Elements of Insight Moment Process - CS2 Archway

Process Step	Input	Action	Output	Representative Quotes	Case Participant
Project Strategy	Identified business need	Assembling the team	Team established	*We typically have a cross-functional team of marketing, engineers, IDHG that are meeting together.*	C2-I3
	Team established	Analysing market research	Defined unmet need	*Team talking through the responses and reactions of surgeons and learning together.*	C2-I3
	Technology input (3D staples)	Explore, talk with team and experts current	Increased understanding of unmet need	*Typically, at the start of the project, we're more in exploratory phase and you're trying to figure out like what that unmet need is. You may have then, kind of talk through how they're using their devices today.*	C2-I3
				Start to understand some of those insights around, like why they're doing this and why they're taking certain steps, you're like, oh, well, if we give you a stronger or improved staple line integrity then, potentially you wouldn't have to take these additional steps in your procedure.	C2-I3
	General identified business need	Market research	Refined unmet clinical need, and identified specific surgery	*We will do qualitative research, like one-on-one interviews with surgeons. And then we'll also do like larger quant studies. And through that process, the customer tells us kind of what their unmet need is.*	C2-I3
				Target Product Profile, describing the unmet need and value proposition, reimbursement strategy.	C2-D1
Understanding the Unmet Need	Refined unmet clinical need	Observation	Refined the unmet clinical need	*I've watched them do this and this is the struggle. It's really a four handed device. So, if I can make it so that they've got more control, right? So, he provided the insight.*	C2-I2

Process Step	Input	Action	Output	Representative Quotes	Case Participant
	Identification of specific surgery	Observation	Refined business need	*We knew we wanted to look at ASL surgery, but we're trying to be unbiased as far as what aspects of that just keep our eyes open for any needs and opportunities within instrumentation or procedure.*	C2-I4
	Identification of specific surgery	Feedback from user	Refined unmet clinical need	*What they told us about that staple line was probably the biggest insight. They said that when there are leaks, lead to complications.*	C2-I3
				Target Product Profile, describing the unmet need and value proposition, reimbursement strategy.	C2-D1
Engaging with Customers	Refined unmet clinical need	Asking questions, VOC	Value statement	*It's what questions you ask and how you ask them and having the right people with the appropriate background to be able to ask those questions is really critical to us getting the right answers.*	C2-I1
				You generate some benefit statements, and you may test it with customers just to get their reaction is okay, what does this mean to you? How valuable is this benefit to you, to your procedures, to your patients?	C2-I3
	Research hypothesis	Market research	Current device usage	*We typically work with a third-party research agency. Oftentimes we go into your research with some sort of hypothesis that you're, you know, you're looking to test sources to see if customers agree, disagree or maybe you just feel differently about it.*	C2-I3
	Revised hypothesis	Asking questions, VOC	Established product architectural	*We started going out and talking early on in the measure phase. Talking to customers about potential architectural solutions, not detailed design.*	C2-I2

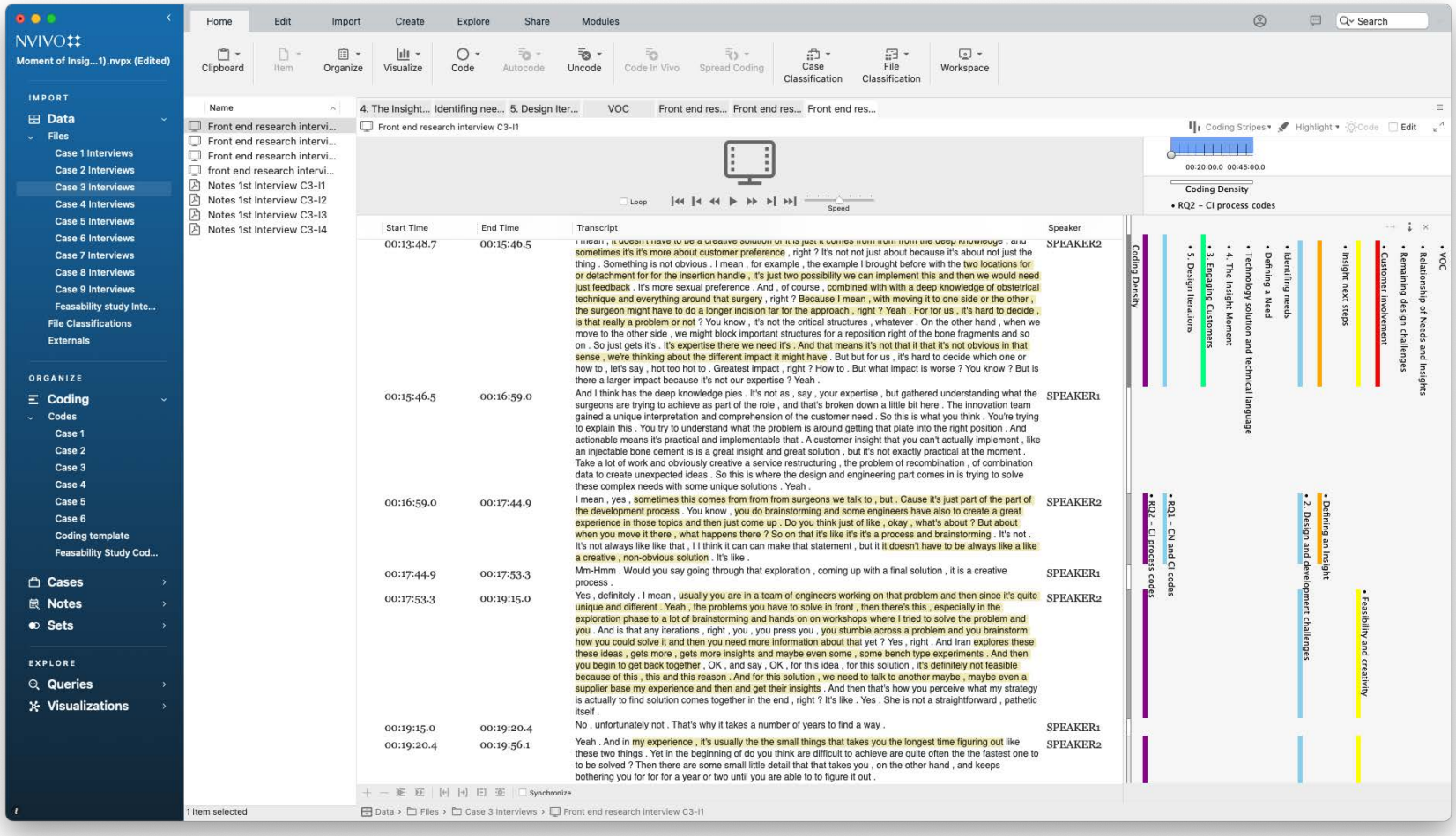
Process Step	Input	Action	Output	Representative Quotes	Case Participant
Iterative Design and Development	Product architecture	Analysis for design options	Create the Design plan	*The design plan is the overarching document from an entity standpoint that outlines the overall project, the goals, the assumptions the deliverables and in there, the opening statement I talk about is what the high-level objectives are, and I specifically mentioned in there this is a mechanical only device. It's not going to include batteries, motors, switches. So, we knew that it was going to be some sort of a mechanism.*	C2-I2
				Design Plan describes the project goals, assumptions, predicate device, and project deliverables.	C2-D2
	Design plan	Testing concepts	Solidified product architecture	*The analyse phase when we start really solidifying what the product architecture is.*	C2-I1
				NPD process.	C2-D4
				Cadence front-end stage B.	CX-D1
	Current device	Observation of surgeries	Current design issues	*I've got a lockout built in so that if the knife is deployed, you can't open the device and expose yourself to the knife. The knife has to be retracted all the way back into the handle. But what happens if either the doctor not knowing or understanding how the device works or he gets himself into a situation where he's cut on something he shouldn't.*	C2-I1
	Current device	Discussion with customers	Performance needs	*Now the footprint of my device has to grow because I've got to fit another staple in, and I know mechanically forming with my hands three rows of staples versus to know my force to fire will go up. These are the trade-offs we need to understand from the customers.*	C2-I1

Process Step	Input	Action	Output	Representative Quotes	Case Participant
	Current device	Observation of surgeries	Usability needs	*They've got to get a new reload and install, so I prevented them from making a use error in the old design, which is good. But it's mostly a nuisance thing, because if the rails are fully loaded and all that sort of stuff, but now they can't inadvertently activate it the old way we've made. We've pokey-yoked against that.*	C2-I1
	Performance needs	Testing	Product requirements workbook	*We actually have requirements on our product requirements workbook that we measure this pull apart force at a certain distance. So, at a certain moment arm and there's a minimum and maximum.*	C2-I2
				Product Requirement, listing the design inputs for the device	C2-D3
	Usability needs	Discussion with customers	Product requirements workbook	*We've gotten rid of the nuisance failures that the doctors have learned to compensate for, but now prevent them from doing that.*	C2-I1
	Current device needs	Existing product analysis	Product requirements workbook	*Sometimes we copy and paste our user needs from other projects or similar platforms where it's like, we have this, you know, we have these general user needs around cleaning and sterilisation or packaging, packaging, sustainability, etc.*	C2-I4
	Product requirements workbook	Discussion with customers	Design Concepts and prototypes	*I think sometimes we think we've got to have a fully fleshed out solution, which we don't have to do but we do have to have it fleshed out to a level where there's the willing suspension of disbelief on the behalf of the surgeon that.*	C2-I1

Process Step	Input	Action	Output	Representative Quotes	Case Participant
Discovering Customer Insights	Design Concepts and prototypes	Reviews of layout out of the product architecture	Customer insights discovered	*That's the work, it is the team sitting down and looking at mechanisms. What we do is we lay out almost on a whiteboard, if you want to think of it that way, of all the requirements that it has to be. It's work you've got to establish that first, whether we see a solution or not.*	C2-I2
				It was around the one hand closure. That's really what it all started with. It all started with that but then realizing, you know, some surgeons want to keep it together. Some surgeons want to take it apart.	
				Target product profile, insight section.	C2-D1
	Design Concepts and prototypes iteration	Reviews of layout out of the product architecture	Customer insights discovered	*The old design was a 2-D staple, and this is a 3-D staple, which means that the staple is formed out of plane. So, your typical staple is simple, two points come down really close. Well, if I actually take those and spread them out a little bit., I've now spread the pressure profile as I'm clamping on that tissue more evenly.*	C2-I1
	Design Concepts and prototypes iteration	Reviews of layout out of the product architecture	Refined design concept	*Used the device with it locked just because they have greater control is one less step than having to lock the devices back together. You know that I think that's the power of the cornerstone design is that you could potentially change the way that surgeons perform the procedures.*	C2-I3

Appendix E – Data Supporting Case Study 3 Barricade

E.1 RQ1 Example Coding of Transcript Interview – CS3 Barricade



E.2 RQ1 Evidence of Understanding Customer Needs, Insights, and their Relationship – CS3 Barricade

Theme	Representative Quotes
Understanding Customer Needs	*You have to decide what user you are; I would really want to call it a motivation. that's the motivation that the basic user need.* (C3-I1)
	The actual product is less known, what's known as the pain point of the customer and the need for benefits and values to be delivered. (C3-I2)
	I think defining the customer and then defining the needs more clearly is important. (C3-I3)
	User needs are centring the person or the people who are going to be actually using the device. User needs the device to be able to do that needs to be satisfied by the device and from those user needs you end up with design inputs or design requirements. (C3-I4)
Understanding Customer Insights	*You ask surgeons, you ask patients about certain ideas you have. And just to get to that feeling of how they have, how they respond. sometimes it's more about customer preference.* (C3-I1)
	I think customer insight, it's our interpretation of a customer's desires or observations of a problem. (C3-I2)
	It's learning what that is through different modes of trying to kind of pull that out. I t's a unique perspective that the customer can provide from an internal perspective versus an external observing perspective. (C3-I3)
	I feel like this definition is combining insights and findings in my brain. Findings the insights are like the things that we observed and learned, and then the findings are the actionable like design implications. (C3-I4)
Relationship of Customer Needs to Customer Insights	*I think a lot of times I view customer needs something that I can easily get a list of 20 things they need done right and insight, and they get two or three out of them. A lot different, and I feel like they're more different than together.* (C3-I2)
	If you don't do that deep insight, you don't provide the actual solution, you might provide a solution that seems to fulfil the customer needs superficially, but long term, so your future benefit may not. It may not do the long provide the long-term benefit that you want because it didn't solve the base problem. (C3-I3)
	From insights, you can get needs. So, insights are things that you're learning. And then the needs will come from the insight. (C3-I4)

E.3 RQ1 Participant's Response to the Customer Need Definition from the SLR – CS3 Barricade

Customer Need Definition Broken down	Explanation	C3-I1	C3-I2	C3-I3	C3-I4	Supporting Quotes	Disconfirming Quotes
A statement crafted by the team	The innovation team analyse the market research data and interprets (crafted) this into a sentence/commentary that captures what the customer wants.	+	+	+	+	*Sometimes the needs are not statements, their observations, or unspoken things, and they're hard to craft into statements.* (C3-I2)	
Reflects the customer's future	Though the customer need is interpreted by the team (reflect), the customer still owns the customer need. As such, the need can change if the market or environment changes for/by the customer (future).	+	+	+	+	*Challenge that is delivering the innovation in the future that we have foreseen seeing and the longer we delay, the less relevant our understanding the need become.* (C3-I2)	
Benefit from and value of a product's use	What will the customer gain (value and benefit), and the job they can perform better (product's use)	+	+	+	+	*I guess reflects the customer's future benefit and value. So, I guess they're saying that if I provide a product that solves a need right, then it has, then it has value. If it doesn't solve their need, then it has no value. So, I see the correlation there.* (C3-I3)	

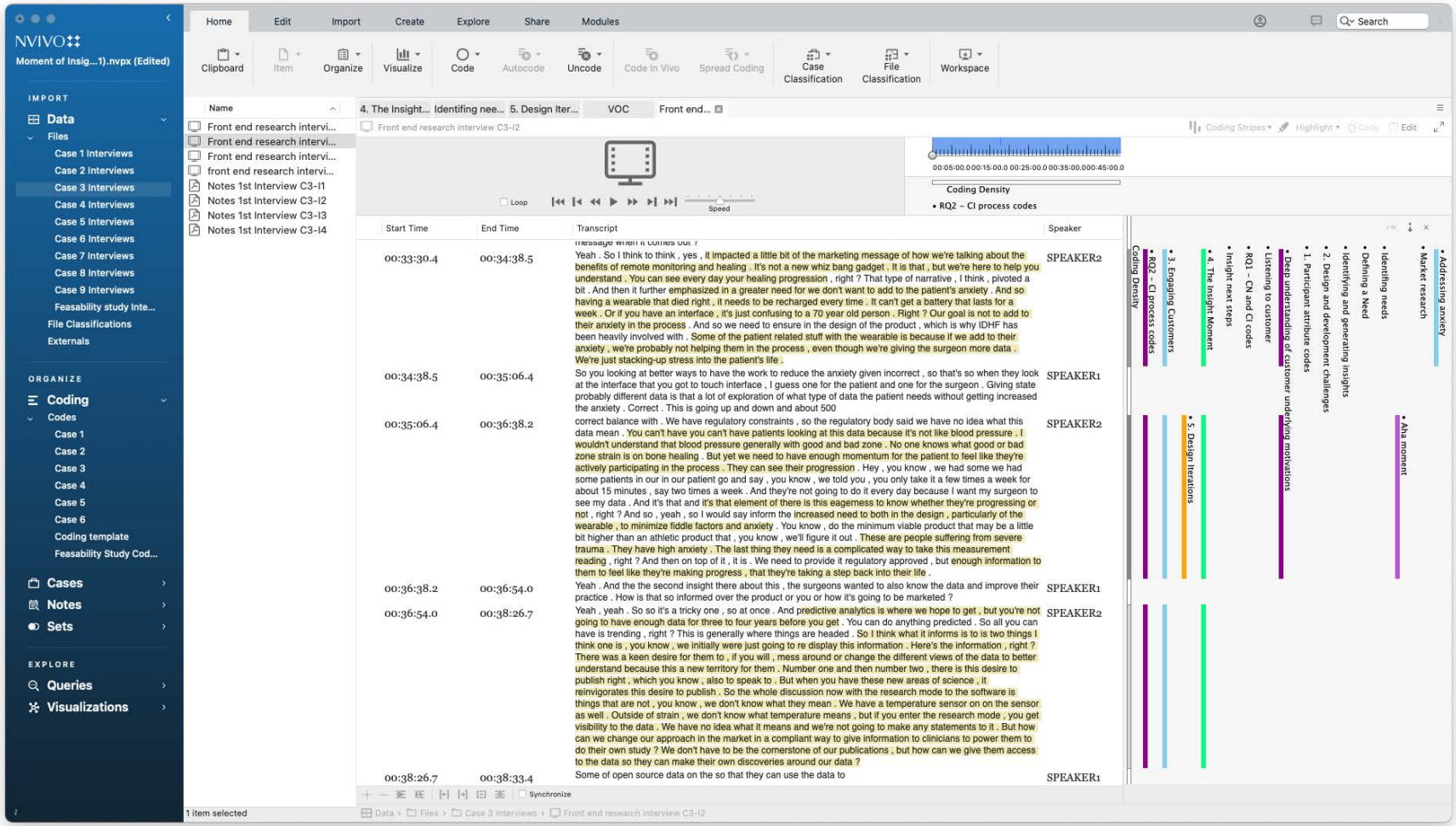
E.4 RQ1 Participant's Response to the Customer Insight Definition from the SLR – CS3 Barricade

Customer Insight Definition Broken down	Explanations	C3-I1	C3-I2	C3-I3	C3-I4	Supporting Quotes	Disconfirming Quotes
Expression of deep knowledge	The innovation team gain a unique interpretation and comprehension of the customer needs and market research data	+	+	+	+	*Often, it's born out of the customer's direct knowledge of their practice or market, but ultimately still is our interpretation of what they said and what they meant.* (C3-I2)	
Actionable	Is practical and implementable	NM	-	NM	+	*Findings the insights are like the things that we observed and learned, and then the findings are the actionable like design implications. finding would be those actionable creative solutions. (C3-I4)*	*I'm not always sure insights are actionable in the traditional sense and by actual, I mean, sometimes the insight isn't that they need another implant, they need another piece of software. It could mean they just need to find a way to keep staff from leaving.* (C3-I2)
Non-obvious, creative	Restructuring the problem and recombining data to create unexpected ideas	-	+	NM	+	*Non-obvious, I actually I love that statement; is that it isn't. Customer insight is something that isn't just laying out on the ground.* (C3-I2)	*it doesn't have to be a creative solution, or it is just it comes from the deep knowledge.* (C3-I1)
Solution		NM	NM	NM	NM		

E.5 RQ1 Participant's Response to the Relationship Between Customer Needs and Customer Insights – CS3 Barricade

Case Participant	Relationship	Sequence	Other Relationship	Representative Quotes by participant
C3-I1	Connected	Not mentioned	Not mentioned	*It has some connection.*
C3-I2	Separate	Not mentioned	NA	*I think a customer need is something that is a little bit more accessible and direct conversation with customers. I feel like they're more different than together.* *I view customer needs something that I can easily get a list of 20 things they need done right and insight, and they get two or three out of them.*
C3-I3	Overlap	Insight to Need	NA	*I think they overlap. I don't think they're the same.* *think the customer need ultimately, if you if you get to the real customer need it comes from deep insight. you need the insight first to get the proper need.*
C3-I4	Communicate with each other	Insight to Need	NA	*Think they do communicate. They are very different concepts, though, but they do communicate.* *From insights, you can get needs. So, insights are things that you're learning. And then the needs will come from the insight.*

E.6 RQ2 Example Coding of Transcript Interview – CS3 Barricade



E.7 RQ2 Analysis: Second and First-order coding for the Insight Moment Process – CS3 Barricade

Second-Order Codes	First-Order Codes	Representative Quotes	Case Participant
Understanding the Unmet Need	Identified unmet need	*The project was born out of a very simple problem that was expressed many times to us by surgeons not saying they need a sensor, they say, the best way I have to understand if my patient is healing is a radiograph and a fluoroscopy. And so that's a point in time, and by the time I see no callus formation coming. It's too late. I can't do anything, right.*	C3-I2
	Market orientation	*What happened in the midst of this was the activity of telemedicine and the acceleration of COVID actually helped a bit to where remote patient monitoring code in the US been issued.*	C3-I2
	Understanding the unmet need	*Sometimes it's quite difficult to check bone healing from just the X-rays.*	C3-I1
	Problem identification	*Finding out what's the problem because other folks that had worked on this project in other ways and other times, we almost went straight to solutions. So, we saw cases where they have like a bar loaded up with gauges, and they immediately were like, oh, that's a supply status, to see if we can make sense of the data and then take out the noise. Whereas like, what's actually going on, what's causing the noise? can we dig even deeper and pull that out.*	C3-I3
Technology Development	Design challenges	*became the development of - How do I repeatedly bond this sensor onto a metallic implant? How do I get that bonding layer to be at the quality threshold? I need to get repeatable. And how do I get the data off in a way that patients are willing to do it and then how do I get the data visualised for surgeons.*	C3-I2
	Feasibility and creativity	*There's no clear solution to find it. You have to find the solution because it's not there yet. And also, no similar product is just out there Yet you're quite free and which are to you. You move as long as it's feasible.*	C3-I1
	Managing innovation	*There is a need for continuity of direction and how you get that may be sheltering a project from leader's eyes. So, I think we did a decent job of allowing research to happen without getting a lot of pressure.*	C3-I2
	Team exploring	*Usually, you are in a team of engineers working on that problem and then since it's quite unique and different. Yeah, the problems you have to solve, especially in the exploration phase to a lot of brainstorming and hands on workshops.*	C3-I1

Second-Order Codes	First-Order Codes	Representative Quotes	Case Participant
Engaging with Customers	Customer involvement	*The customers for us sometimes are the surgeons, but less so the patients. Sometimes it's the nursing staff. So, it's defining who the customer is, it's understanding what their needs are that takes different forms.*	C3-I3
	Ethnography and observation	*You're watching them and it's not that might be expressed by the customer that they need to have a better solution.*	C3-I4
	Exploring ideas	*We initially were just going to display this information. Here's the information, right? There was a keen desire for them to mess around or change the different views of the data to better understand because this a new territory for them.*	C3-I2
	Future customer learning	*But then they have all these questions around all these different formats of how they load up the plate. You know where the fracture is relative to the sensor, what happened at the plate actually bends in the process.*	C3-I2
	Listening to customer	*One thing that they did extremely well is feeling the customer needs and desires and ambitions and a very continuous basis. Like, we had a very continual communication line with customers on multiple levels.*	C3-I2
	Market research	*We did patient research that were from former fracture patients.*	C3-I2
	Need questions	*Sometimes you come with specific questions to a certain user group for feedback. For example, we need to move the insertion handle from a certain spot on the plate to accommodate the sensor on the other spot, which can certainly be used to attach. And we did get ready to implement this, you know? But we had no idea which one the surgeon would prefer.*	C3-I1
	Needs and design requirements	*You can't have patients looking at this data because it's not like blood pressure. I wouldn't understand blood pressure generally with good and bad zone. No one knows what good or bad zone strain is on bone healing.*	C3-I2
	Types of users	*Surgeons use the implant during a trauma surgery, but not with smart plate. We have like also the patient as a user.*	C3-I1
	VOC	*Like a VOC, you ask surgeons, you ask patients about certain ideas you have for that patient wearable we had some initial VOC. They were conducted by the IDHF team.*	C3-I4

Second-Order Codes	First-Order Codes	Representative Quotes	Case Participant
Discovering Customer Insights	Addressing anxiety	*There was one lady in particular who said 'I broke my leg. And for a month, was I convinced I would never walk again, even though the doctor said I would recover fine'. And so, for a month, she lived in terror that she was going to be bedridden and never walk. And that sense of that weight of fear and anxiety and the disruption that provides to life was something that was just shocking to me. And so, the basic utility for a patient to see incremental progression of the strain right, that yeah, her body is starting to take, incrementally the ability to relieve that anxiety and stress in that patient for a month.*	C3-I2
	Aha moment	*The solution ended up being fairly simple. You can buy I mean, we're not using standard off the shelf, but in our testing we were. And you can buy rosettes. You can buy a gauge that has all three of these on there and you collect the data, you're sending it through the same equation. And all of a sudden, we saw all of our data and starting to line up so that hitting the problem.*	C3-I3
	Benefits and values	*People who are really invested in their health or, you know, more Type-A personalities who really feel like they want to have control over the things they want as much data as possible. They want to be involved in every step of their care. Versus people who are like, and I go to the doctor, they tell me I'm good or I'm not and, I go on with my day, but you know what value? Again, going back to the value and the value proposition type work, what value is this actually bringing to patients.*	C3-I4
	Deep understanding of customer underlying motivations	*The user needs to be able to do or things that the user needs the device to be able to assist them with to be able to achieve the goal of using that thing.*	C3-I4
	Future solutions	*We can add more and gain probably more insight across, not just related to bone hearing, but maybe related to strain and stiffness of the plates, which can lead us towards maybe learning how different plates need. Are they too stiff or too, because you can start to associate now healing with plate strains.*	C3-I3
	Technology solution and technical language	*The actual solution to the problem itself was more technically driven and less by surgeons needs or patient need.*	C3-I1
Iterative Design and Development	Concept design challenges	*The designer has been working with IT and the Velys team to figure out whether the things that she's designed can actually be coded and produced. So that kind of goes back to the whole intersection of user needs or insights with where technology is.*	C3-I4

Second-Order Codes	First-Order Codes	Representative Quotes	Case Participant
	Design concepts	*The videos for the surgeons, for the implantation will be more like in the very end after all of the product, because the surgical technique for implantation of smart plate will be pretty much the same from a standard plate.*	C3-I1
	Development	*Going back and redesigning and then putting it in front of users again and seeing whether your solutions satisfy those needs.*	C3-I4
	Insight next steps	*We need to show that the surgeons are able to interpret the data correctly and that they are not coming to a wrong diagnosis based on this data. So, this is where the customer insights come in.*	C3-I1
	Remaining design challenges	*Patient reader unit is currently in development, we are working on the prototype for, which is then fully functional. A few days post-op the nurse has to register the patient at the end of the portal because we need to connect to the unique ID of the plate, which then sends off that data to the portal.*	C3-I1
	Usability	*The whole user interface that's a little remote, the patient has to put it on again just a couple of times a week for a few minutes to take readings and a snapshot in time.*	C3-I4

E.8 RQ2 Data Structure – CS3 Barricade

Code Name	References
RQ2 - CI process codes	167
Understanding the Unmet Need	33
Identified unmet need	9
Market orientation	7
Problem identification	10
Understanding the unmet need	7
Technology Development	19
Design challenges	5
Feasibility and creativity	4
Managing innovation	4
Team exploring	6
Engaging with Customers	48
Customer involvement	6
Ethnography and observation	2
Exploring ideas	6
Future customer learning	4
Listening to customer	4
Market research	6
Need questions	2
Needs and design requirements	9
Types of users	1
VOC	8
Discovering Customer Insights	32
Addressing anxiety	4
Aha moment	5
Benefits and values	3
Deep understanding of customer underlying motivations	3
Future solutions	3
Technology solution and technical language	14
Iterative Design and Development	55
Concept design challenges	1
Design concepts	3
Development	8
Insight next steps	27

Code Name	References
Remaining design challenges	5
Usability	11
Blanks	
Creativity and imaginative thinking	
Design - user, human-centred, empathic, thinking	
Dynamic and evolving needs	
Gestalt	
Own words	
Radical, incremental innovation	
Transforming data into meaningful knowledge	
Unarticulated, tacit, latent, unconscious	

E.9 RQ2 Practices and Elements of Insight Moment Process – CS3 Barricade

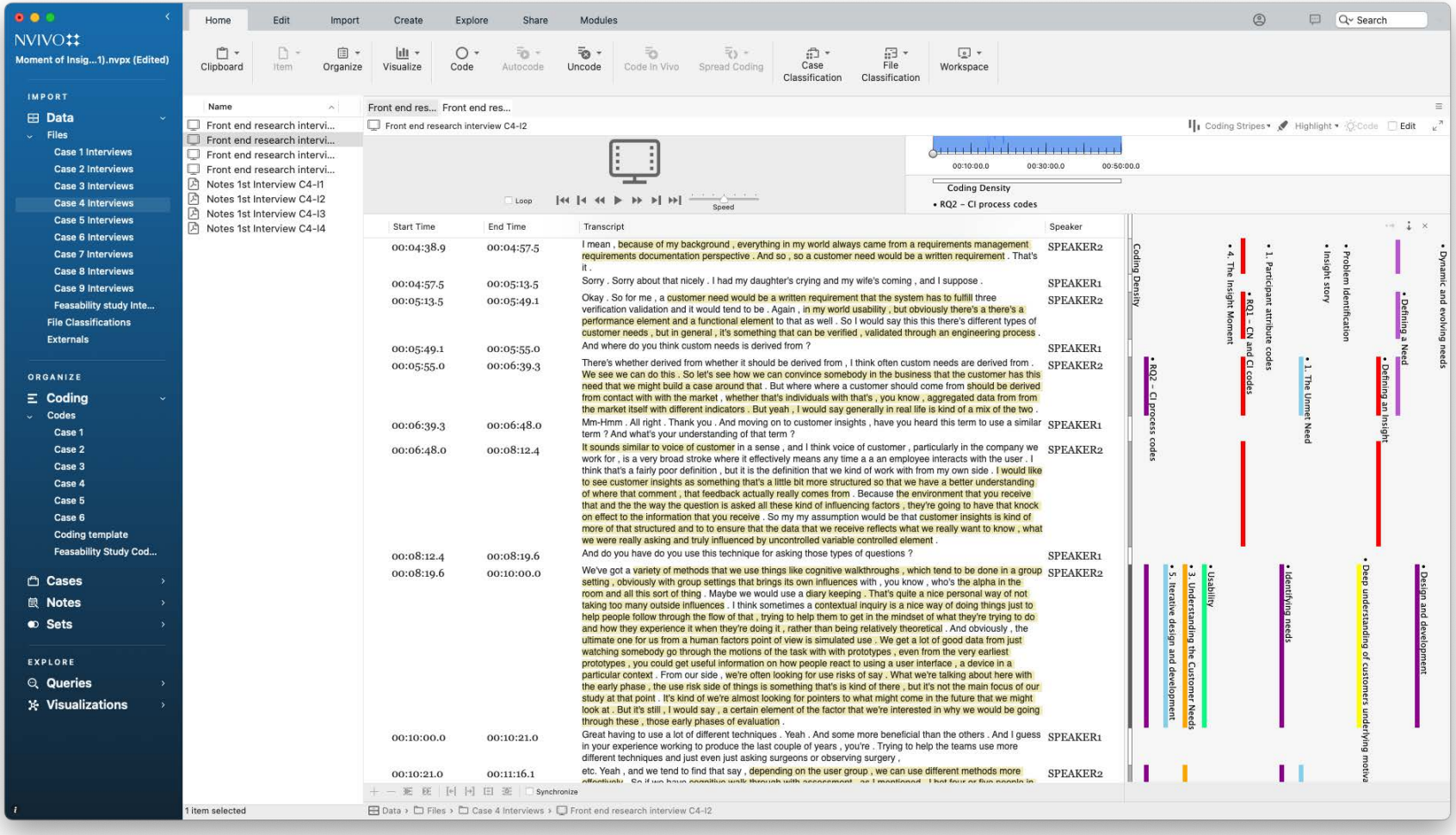
Process Step	Input	Action	Output	Representative Quotes	Case Participant
Understanding the Unmet Need	Unmet clinical need	Assembling the team Technology landscape search	Identified Technology	*Project ultimately is to measure strain on plate, deliver that information to the physician who can track that during the patients The theory is that the strain on the plate near the fracture should decrease over time as the patient heals.*	C3-I3
				TPP, outlining the unmet clinical need and market assumption.	C3-D1
	Identified Technology, feasibility concept	Brainstorming and internal workshops	Defined unmet clinical need	*Usually, you are in a team of engineers working on that problem and then since it's quite unique and different. Yeah, the problems you have to solve, especially in the exploration phase, a lot of brainstorming and hands on workshops where I tried to solve the problem.*	C3-I1
Technology Development	Refined unmet clinical need	External partnering	Feasibility concept	*We partnered with a company who helped some of the foundational research that was done to involve the sensor design to make it stable and repeatable to measure the strain.*	C3-I2
	Feasibility concept	Brainstorming and internal workshops	List of technical questions	*I think there's a bunch of questions there that have not been answered yet.*	C3-I4
Engaging with Customers	List of questions	Engage surgeons	Identified preliminary needs	*we had no idea which one the surgeon would prefer. So, you come with specific questions to specific use group together to the direction before you because it doesn't make sense for first timers to develop to path right.*	C3-I1
				Product questionnaires provide a basis for interview surgeons on the smart plate.	C3-D2

Process Step	Input	Action	Output	Representative Quotes	Case Participant
				One thing that they did extremely well is feeling the customer needs and desires and ambitions and a very continuous basis. Like we had a very continual communication line with customers on multiple levels.	C3-I
	Identified needs	Ideas and concepting	Concept Prototype	*You look for a certain number of customers of a certain group and test basically your product.*	C3-I
	Concept Prototype	Engage surgeons	Refine concept Prototype	*Surgeons, even though they were trained in biomechanics, they haven't had access to this data So there's questions like, well if I mix, which ones are you like, you screw the non-working screws that have a screw brace. What does the data mean. How do the sensors change? But then they have all these questions around all these different formats of how they load up the plate.*	C3-I
	Refine concept Prototype iteration	Customer (surgeon, nurse, patient) testing	Refine concept Prototype iteration	*Patient needs to take measurements at home by himself. And that becomes a lot of other user needs in their tests.*	C3-I1
	Refine concept Prototype iteration	Observation	Procedure mapping	*You're watching them and it's not that might not be expressed by the customer that they need to have a better solution.*	C3-I1
	Refine concept Prototype iteration	VOC	List of customer needs	*Like a VOC, you ask surgeons, you ask patients about certain ideas you have for that patient wearable we had some initial VOC. They were conducted by the IDHF team.*	C3-I4
				Requirement Traceability Matrix, provides a list of the product requirements and customer needs.	C3-D3
Discovering Customer Insights	Refined design concept	Patient engagement	Patient involvement	*Some of the patient related stuff with the wearable is because if we add to their anxiety, we're probably not helping them in the process, even though we're giving the surgeon more data. We're just stacking-up stress into the patient's life.*	C3-I2

Process Step	Input	Action	Output	Representative Quotes	Case Participant
	Refined concept	Exploring uses	Other applications identified	*We can add more and gain probably more insight, not just related o bone hearing but maybe related to strain and stiffness of the plates, which can lead us towards maybe learning how different plates need to be like. You can do more, but there's limitations with the technology.*	C3-I3
	Refined concept	Solving technical issue	Plate design solution	*We have these issues with the coating. We have to come with a quite unique solution there. So, it's basically a mix of a glass box and the coating at the end because just one single solution that didn't work, we had to build multiple step barriers.*	C3-I1
	Refined concept	Solving technical issue	Plate design solution	*We found a way to remove confounding factors like patient's weight and other things by putting two sensors on the implant.*	C3-I3
Iterative Design and Development	Patient involvement User interface	Developing and testing of user interface	Refined wearable concept	*We started off with the basic concept to plate itself. And now comes the part where we need the customer insight when we because we're currently at developing the patient wearable.*	C3-I1
	Developing of user interface	User testing	Refined wearable concept	*Increased need to both in the design, particularly of the wearable, to minimize fiddle factors and anxiety.*	C3-I1
	Design concept	Iterative design	Refined UI concept	*How do I get patients to easily extract the data off because they're going to be at home? And then how do I allow care teams to visualise that data in a meaningful way so they understand we would talk to the FDA? One of their big concerns was what will clinicians do with this data?*	C3-I2
	Design concept	Iterative design	Wearable device	*Then you reiterate again, and you come up with different solutions to those needs or wants. And then, yeah, theoretically, your kind of just keep going until all of the needs have been satisfied. All of the risks have been mitigated appropriately and then you're golden.*	C3-I4

Appendix F – Data Supporting Case Study 4 Amalgam

F.1 RQ1 Example Coding of Transcript Interview – CS4 Amalgam



F.2 RQ1 Evidence of Understanding Customer Needs, Insights, and their Relationship – CS4 Amalgam

Theme	Representative Quotes
Understanding Customer Needs	*The customer is saying that they need from a from a device or from a new device. they're finding where they can't do exactly what they want to do and what their frustrations are. That kind of thing or even ideas for development and future progression.* (C4-I1)
	I would say a customer need is something that you'd probably be identifying early on. Maybe you break it down to some requirements, but ultimately is that so that's some point you're going to verify that you delivered when you intended. (C4-I2)
	When someone articulate so you observe them doing something that is like a pain point, a challenge or a one. It's that translation of what are they actually asking for into us? Sort a needs statement is kind of where I would go with that. (C4-I3)
	When I think about customer needs, I think about the end customer, so the patient will ultimately receive the product as well as the surgeon who is implanting products. (C4-I4)
Understanding Customer Insights	*This digging into the depths of the user need to provide something that meets and exceeds their user need is an insight. It is a deep dive into what's going on.* (C4-I1)
	Customer insights is kind of more structured and ensure that the data that we receive reflects what we really want to know, what we were really asking and truly influenced by uncontrolled variable controlled element. (C4-I1)
	I think to me that's more observed. So, if you're doing ethnographic research or something like that and you see them do something in a certain way. There's a term for it that alert behaviour. they're doing it in an unexpected way, they've learned how to do it in their own way to overcome that challenge. That's kind of giving you those insights. Things that aren't readily available. (C4-I3)
	Customer insights is understanding what it is that a customer desires to have. I would also say what is their definition of success (C4-I4)
Relationship of Customer Needs to Customer Insights	*The realization of the solution into what they're telling us they need. To improve their outcomes and patient outcomes.* (C4-I1)
	Customer insights seem more like something that you would do to help you meet those customer needs. The need defines the product and its delivery and the verification, whereas the customer insight is creative. (C4-I2)
	I think they should overlap, the needs are probably like the building blocks of your projects, and then I think insights potential enhancements. You could build a project of needs and it was something that there that market might want or whatever you want to term it. But if you want to truly innovate and do something different, then you need to build the insights into that. (C4-I3)
	I would say that a customer need would be nested inside customer insights. Customer insights would be a broader category of understanding of your customer. Don't seem to be linked in that type of way. (C4-I4)

F.3 RQ1 Participant's Response to the Customer Need Definition from the SLR – CS4 Amalgam

Customer Need Definition Broken Down	Explanation	C4-I1	C4-I2	C4-I3	C4-I4	Supporting Quotes	Disconfirming Quotes
A statement crafted by the team	The innovation team analyse the market research data and interprets (crafted) this into a sentence/commentary that captures what the customer wants.	+	+	+	+	*Gather into themes based on the themes develop a user needs statement, we've developed a statement to say this is what customers are telling us.* (C4-I1)	
Reflects the customer's future	Though the customer need is interpreted by the team (reflect), the customer still owns the customer need. As such, the need can change if the market or environment changes for/by the customer (future).	+	+	+	+	*What their frustrations are. That kind of thing or even ideas for development and future progression.* (C4-I1*)*	
Benefit from and value of a product's use	What will the customer gain (value and benefit), and the job they can perform better (product's use)	NM	+	+	+	*Customer needs that would be defining what is it that customer aspires to have available to them to meet the needs of their customers.* (C4-I4)	

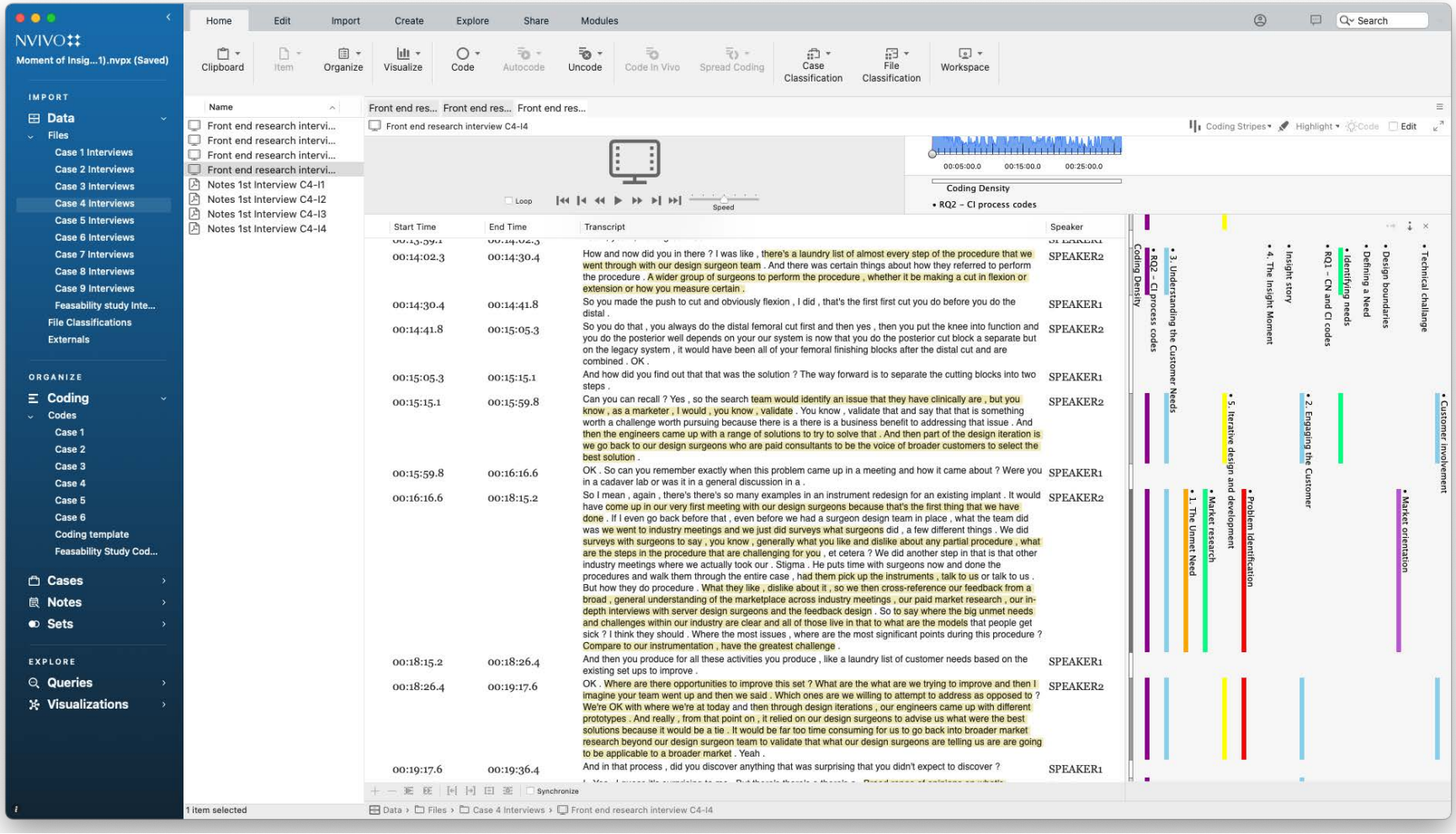
F.4 RQ1 Participant's Response to the Customer Insight Definition from the SLR – CS4 Amalgam

Customer Insight Definition Broken down	Explanations	C4-I1	C4-I2	C4-I3	C4-I4	Supporting Quotes	Disconfirming Quotes
Expression of deep knowledge	The innovation team gain a unique interpretation and comprehension of the customer needs and market research data	+	+	+	+	*Digging into the depths of the user need and the customer need to provide it, provide something that meets and exceeds their user need.* (C4-I1)	
Actionable	Is practical and implementable	NM	+	+	+	*Whether an insight is actionable or not, sometimes it could be context. I think actionable. I'm just thinking about those times when could kind of interpretation and comprehension of the customer need completely and fair to say that rather than actionable, they would be in practical and implementable. In a use environment where there's certain type of lighting and the light is bright, and it's got certain colour qualities. And that makes the use of other colours on displays. all those kinds of environmental factors. I guess that's actionable. But otherwise here, I think that's a good statement.* (C4-I2)	
Non-obvious, creative	Restructuring the problem and recombining data to create unexpected ideas	+	+	NM	+	*Kind of actionable, non-obvious piece, would we end up in that space rather than trying to plug a gap.* (C4-I3)	
Solution		+	NM	NM	NM	*A realization of the solution into what they're telling us they need. To improve their outcomes and patient outcomes.* (C4-I1)	

F.5 RQ1 Participant's Response to the Relationship Between Customer Needs and Customer Insights – CS4 Amalgam

Case Participant	Relationship	Sequence	Other Relationship	Representative Quotes by Participant
C4-I1	Similar	Not mentioned	Not mentioned	*An insight feels similar to a customer need.*
C4-I2	Subset	Need to Insight	Need – base requirement Insight – creative	*Customer insights seem more like something that you would do to help you meet that customer needs. The need defines the product and its delivery and the verification. Whereas the customer insight is creative. And so, it's a designed influence that helps you to meet the customer need.*
C4-I3	Overlap	Need to Insight	Need – base requirement Insight – enhancement	*I think they should overlap. the needs are probably like the building blocks of your project, and then I think insights are potential enhancements.*
C4-I4	Need nested in insights	Insight to Need	Not mentioned	*I would say that a customer need would be nested inside customer insights. Customer insights would be a broader category of understanding of your customer.*

F.6 RQ2 Example Coding of Transcript Interview – CS4 Amalgam



F.7 RQ2 Analysis: Second and First-order coding for the Insight Moment Process – CS4 Amalgam

Second-Order Codes	First-Order Codes	Representative Quotes	Case Participant
Understanding the Unmet Need	Market orientation	*The surgeon team that we've accumulated for the project use both mobile and fixed bearing system. Mobile bearing system is a bit by far and away the biggest system on the market. We're trying to tap into that market and expand our market share.*	C4-I1
	Market research	*I think we've got about feedback from 200 odd surgeons, so we had a rough idea of where the pain points and challenges were in the workflow.*	C4-I3
	Team	*Developing engineers, design engineers and industrial design would have been involved.*	C4-I1
Engaging with Customers	Customer involvement	*Design surgeons who are paid consultants to be the voice of broader customers to select the best solution. It relied on our design surgeons to advise us what were the best solutions.*	C4-I4
	Engaging customers	*It will start with interviewing surgeons, be it at a conference or direct one on one interviews.*	C4-I1
	Ethnography and observation	*Ultimate one for us from a human factors point of view is simulated use. We get a lot of good data from just watching somebody go through the motions of the task with prototypes, even from the very earliest prototypes, you could get useful information on how people react to using a user interface, a device in a particular context.*	C4-I2
	Listening to customer	*Broad range of opinions on what's important. It was surprising or I would have thought that there would be more consensus across the kit. There was a lot more discussion about the finer details of each instrument than I suspect that we were going to have.*	C4-I4
	VOC	*We've got a big VOC report and a report that then takes in-use and needs.*	C4-I1
Understanding the Customer Needs	Deep understanding of customers underlying motivations	*There was a lot of time trying to understand what we wanted to achieve. Before putting pencil to paper and starting to develop a prototype new design.*	C4-I1
	Dynamic and evolving needs	*Check-ins with your needs, help along the process, I think sometimes we generate them at the beginning, and they stay there, whereas if you continuously pull them through, you've got things like task analysis that you can go into and make sure you're mitigating, or you've got a track of why you've done it.*	C4-I3

Second-Order Codes	First-Order Codes	Representative Quotes	Case Participant
	Identifying needs	*Gather into themes based on the themes develop a user needs statement.*	C4-I1
	Problem Identification	*Where are these opportunities to improve this set? What are we trying to improve? Which ones are we willing to attempt to address as opposed to we're OK with where we're at today.*	C4-I4
	Unarticulated, tacit, latent, unconscious	*What people say they do and are they actually do with two different things. And I think that's the crux of sort of user needs analysis that you need to observe to understand.*	C4-I3
Discovering Customer Insights	Aha	*There were two big AHA moments. It was a small technical development and technical aha moments are how to achieve them. How to achieve the product. There's nothing that links back to a specific user need, I guess, or customer feedback.*	C4-I1
	Identifying and generating insights	*I think back to the instruments and when we started the way that we gained insights was we called it a heaven and hell session where we said, what are the things that you love about the implants and the instrument systems that exist today.*	C4-I4
	Innovation type	*The end of the day is still a manual knee surgery procedure. There are step forward in innovation, undoubtedly. Let's say it's a small step rather than a giant leap in innovation.*	C4-I1
	Insight emotion	*There was a difference. It was a definite feeling. This delivers what we want to deliver, gives improvements, gives efficiencies. Gives a more stable platform for further cuts and further preparation.*	C4-I1
	Insight story	*To achieve a balanced outcome started discovering little nuances in partial knee surgery that haven't been well explained, haven't been well understood. Delivering the solution to allow both in one kit without having a completely separate surgical technique to manage different philosophies.*	C4-I1
Iterative Design and Development	Industrial design	*What we decided to do was try and bring the design language fit. It was a more familiar kit, build up that heritage, but make it a more approachable kit effectively.*	C4-I3
	Design and development	*The original prototype, you can see roughly where the link is to the final product.*	C4-I1
	Design boundaries	*So, there is the instrument redesign, which is fenced by the implant that we already have today, that we had to stick to. We had to play within those boundaries. And then you have the implant side, which as we defined it was more of a white space.*	C4-I4

Second-Order Codes	First-Order Codes	Representative Quotes	Case Participant
	Design solutions	*The engineers came up with a range of solutions to try to solve that. And then part of the design iteration is we go back to our design surgeons.*	C4-I4
	Design iterations	*Through design iterations, our engineers came up with different prototypes. And really, from that point on, it relied on our design surgeons to advise us what the best solutions were because it would be a tie. It would be far too time consuming for us to go back into broader market research beyond our design surgeon team to validate that.*	C4-I4
	Emergent design problems	*I think doing more formative testing would have identified that a lot earlier.*	C4-I3
	Technical challenge	*The biggest change will be its fixation method.*	C4-I1
	Usability	*We're often looking for use risks. What we're talking about here with the early phase, the use risk side of things is something that's is kind of there, but it's not the main focus of our study at that point.*	C4-I2

F.8 RQ2 Data Structure – CS4 Amalgam

Code Name	References
RQ2 - CI process codes	230
Understanding the Unmet Need	31
Market orientation	10
Market research	17
Team	4
Engaging with Customers	37
Customer involvement	6
Engaging customers	9
Ethnography and observation	8
Listening to customer	10
VOC	4
Understanding the Customer Needs	63
Deep understanding of customers underlying motivations	9
Dynamic and evolving needs	4
Identifying needs	34
Problem Identification	15
Unarticulated, tacit, latent, unconscious	1
Discovering Customer Insights	55
Aha	1
Identifying and generating insights	10
Innovation type	4
Insight emotion	1
Insight story	39
Iterative design and development	44
Design and development	6
Design boundaries	3
Design iterations	3
Design solutions	8
Emergent design problems	4
Industrial design	5
Technical challange	3
Usability	12
Blanks	0
Benefits and values	0

Code Name	References
Creativity and imaginative thinking	0
Design - user, human-centred, empathic, thinking	0
Gestalt	0
Own words	0
Radical, incremental innovation	0
Technology solution and technical language	0
Transforming data into meaningful knowledge	0

F.9 RQ2 Practices and Elements of Insight Moment Process – CS4 Amalgam

Process Step	Input	Action	Output	Representative Quotes	Participant Code
Understanding the Unmet Need	Competitor market disruption	Business Insights General surgeon input, surveys Journal review	Unmet business need	*What they like, dislike about it, so we then cross-reference our feedback from a broad, general understanding of the marketplace across industry meeting, our paid market research, our in-depth interviews with design surgeons and the feedback design.*	C4-I4
	Unmet business need	Third party marketing research	Defined unmet clinical need	*We will work with a third-party market research company outlining what's the objective. We're trying to understand and then structure an interview process.*	C4-I4
				Instruments User Needs and Intended Uses Report, listed the unmet need, customer needs and usability requirements.	C4-D1
Engaging with Customers	Defined unmet clinical need	Surgeon survey	Market Research	*I think we've got about feedback from like 200 odd surgeons. So, we had a rough idea of where the pain points and challenges were in the workflow.*	C4-I1
	Defined unmet clinical need	Surgeon interview	Market Research	*It will start with interviewing surgeons, be it at a conference or direct one on one interviews.*	C4-I1
	Defined unmet clinical need			VOC summary presentation provided a detailed assessment of the market research work.	C4-D2
	Defined unmet clinical need	Surgery observation and interviews	Identified issues	*The need came from direct observation and what they're telling us. We did go out to observe surgeries to see what was going on.*	C4-I1
	Defined unmet clinical need	Surgeon co-design	Design ideas	*And I think we got the surgeons involved in that. So, we got them drawing and post-it notes like that co-design.*	

Process Step	Input	Action	Output	Representative Quotes	Participant Code
	Existing instrument design	Simulated use of existing devices	Identified issues	*A cadaver lab where they use the existing instruments. The workflows are kind of coming in and people are trying to use the instruments in a way that's different.*	C4-I3
	Existing instrument design	Simulated use of existing devices	Identified issues	*Broad range of opinions on what's important. It was surprising or I would have thought that there would be more consensus across the kit. There was a lot more discussion about the finer details of each instrument than I suspect that we were going to have.*	C4-I4
Understanding the Customer Needs	Market Research	Interpreting market research data	Identified needs	*Just trying to understand there was a lot of time trying to understand what we wanted to achieve. Before putting pencil to paper and starting to develop a prototype new design.*	C4-I1
	Design ideas	Team brainstorming	Identified needs	*Certainly, by engineers and design engineers and industrial design. Don't remember marketing being involved in those brainstorming session.*	C4-I1
	Market Research	Interpreting market research data	Initial need statement list	*It was fairly early in the development process when we when we covered all user needs, started generating the direct user, need statements.*	C4-I1
	Identified issues	user needs analysis	User needs report	*There's a laundry list of almost every step of the procedure that we went through with our design surgeon team.*	C4-I4
	Identified issues	user needs analysis	User needs report	*What people say they do and what they actually do are two different things. And I think that's the crux of sort of user needs analysis that you need to observe to understand.*	C4-I3

Process Step	Input	Action	Output	Representative Quotes	Participant Code
	User needs report	Check review	Revised user needs report	*Check-ins with what your needs help along the process, I think sometimes we generate them at the beginning, and they stay there, whereas if you continuously pull them through, you've got things like Task and Use analysis that you can go into and make sure you're mitigating against those, or you've got a track of why you've done it.*	C4-I3
	Revised user needs report	Review of needs	Concepts designs	*We have to remove that bias and make sure that need is a general need that they actually want or need. I think you've just got to validate those to make sure they are actual needs*	C4-I3
	Concepts designs	Validate needs with customers	Concepts designs iteration	*You base a full project on that one thing and then realise that it's actually all the steps before it then led to that issue that you've got to fix.*	C4-I3
	Concepts designs iteration	Simulated use of prototypes	Concepts designs iteration	*We had a big excel sheets of hundreds of observations where we thought we'd run the test; test deviation or administrative guidance would intervene, and all the errors associated with each of the individuals who took part.*	C4-I2
	Concepts designs iteration	Simulated use of prototypes	Prototype design	*Ultimate one for us from a human factors point of view is simulated use. We get a lot of good data from just watching somebody go through the motions of the task with prototypes, even from the very earliest prototypes, you could get useful information on how people react to using a user interface.*	C4-I2
				I think there's been a little bit too much of saying, oh, the surgeon design team said it should be blue. Rather than exploring around that a little bit more to understand what that really means and the impacts on what that would do, including people who don't have that level of experience that they do.	C4-I2

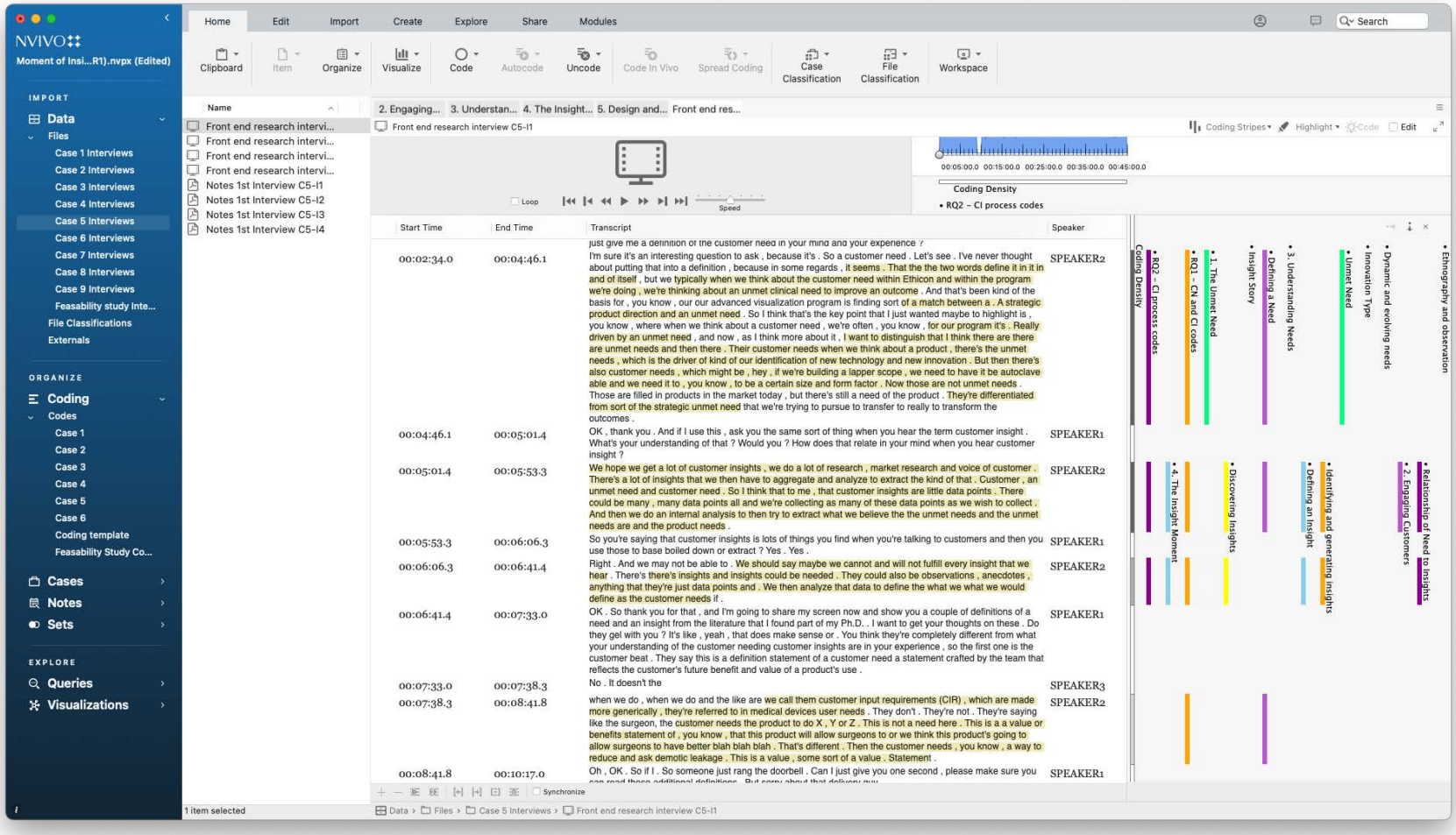
Process Step	Input	Action	Output	Representative Quotes	Participant Code
Discovering Customer Insights	Prototype design	Brainstorming ideas	Revised prototype	*The customer need that was - Better the way to prepare the tibia more accurately, more with a more stable solution, more quickly as well. That's insight and is a very close product, a reciprocating saw based on the AHA moment.* *Two parallel reciprocating saw blades that go down into a slot to prepare most of the cavity, which then needs an osteotome to clean act. We went that one step further and said, well, why can't it do the whole thing. Developed to a reciprocating saw that can prepare, a complete cavity of the tibial keel. Whilst managing of the methods of securing the tip, your base faceplate, it's a little preparation place with pin ins changing the angle of the of the peg drill to get better access to the to the tibia.*	C4-I1
	Prototype design	Design review with surgeons	Revised prototype	*There was a difference. It was a definite feeling, particularly when presented to the researcher . And this is it. This delivers what we want to deliver, gives improvement, gives efficiencies, gives a more stable platform for further cuts and further preparation.*	C4-I1
	Revised prototype	Observation Videos , Brainstorming ideas	New customer insights and needs	*The second one was recorded . It wasn't necessarily coming directly from the customer. They wanted to have better control of several rotations and their gaps, flexion and extension gaps to balance the knee. To achieve a balanced outcome started discovering little nuances in partial knee surgery that haven't been well explained, haven't been well understood. We developed a solution to manage both, essentially, and improve the delivery and execution of putting the final component in place to achieve a good surgical outcome.*	C4-I2

Process Step	Input	Action	Output	Representative Quotes	Participant Code
	Revised prototype	Observation Videos , Brainstorming ideas	New customer insights and needs	*What tends to happen after a few of these is say we start to see a lot of this type of issue and we start to see a group of these around here. And so we were looking for patterns. We're looking for things that not necessarily pattern in the sense of where they happened during the workflow, but are happening for the same reason.*	C4-I2
	Revised prototype	Observation Videos , Brainstorming ideas	New customer insights and needs	*We realised it was two work flows. So we had surgeons execute into the sigma HP workflow . But then we had about three or four that were basically creating their own workflow where they had to shave a bit off the posterior condyle . So that was probably one of those insights of can we instrument those two technique?*	C4-I3
Iterative Design and Development	Prototype design	Simulated use of prototypes	Revised prototype	*You looked at a number of solutions in that space before settling on a reciprocating saw. Again, iterating through and understanding.*	C4-I1
	Prototype design	Simulated use of prototypes	Revised prototype	*Numerous, numerous prototype and design iterations before we raced to find a solution.*	C4-I1
	Prototype design	Simulated use of prototypes	Revised prototype	*There's a tendency to think of usability as that thing you do at the end just to make sure it's really OK. And so there's almost like a fig leaf approach to to usability.*	C4-I2
	Prototype design	Develop design lanuguage and branding	Revised prototype	*What we decided to do was try and make the design language fit. It was a more familiar kit . Build up that heritage, but make it more of a What did the term that we used wanted it to be?, like an approachable kit effectively.*	C4-I3

Process Step	Input	Action	Output	Representative Quotes	Participant Code
	Prototype design	Design review with surgeons	Revised prototype	*The engineers came up with a range of solutions to try to solve that And then part of the design iteration is we go back to our design surgeons.*	C4-I4
	Prototype design	Design review with surgeons	Revised prototype	*Then through design iterations , our engineers came up with different prototypes. And really, from that point on, it relied on our design surgeons to advise us on what were the best solutions because it would be a tie. It would be far too time-consuming for us to go back into broader market research beyond our design surgeon team to validate that what our design surgeons are telling us are are going to be applicable to a broader market.*	C4-I4

Appendix G – Data Supporting Case Study 5 Minerva

G.1 RQ1 Example Coding of Transcript Interview – CS5 Minerva



G.2 RQ1 Evidence of Understanding Customer Needs, Insights, and their Relationship – CS5 Minerva

Theme	Representative Quotes
Understanding Customer Needs	*When we think about the customer need and within the program we're doing, we're thinking about an unmet clinical need to improve an outcome.* (C5-I1)
	Understanding different needs and kind of evaluating the customer experiences is something that we like to hang our hat on with that evaluation process. (C5-I2)
	At the end of the day, what the customer wants is what the customer wants, regardless of what we can deliver. (C5-I3)
	Customer needs, my mind automatically goes to unmet needs. So, my definition will be supportive of unmet needs, but it's really about what our surgeons and clinicians or economic stakeholder, hospital stakeholders and our customers need today that they don't have in their current operating room experience or to do their job better gets in the mind of that stakeholder. (C5-I4)
Understanding Customer Insights	*I think the customer insights are a collection of data points that that the teams, they go out into the field, whether they be through market research activities or whether they be through observations. But it's collecting a lot of data points, which are customer insights.* (C5-I1)
	The nugget of information that allows you to do something different to support that need, that gives you a kind of a glimpse into why that need is important and how you might deliver. (C5-I2)
	Insight is that in my mind, the nugget of information that allows you to do something different to support that need, that gives you a kind of a glimpse into why that need is important and how you might deliver. (C5-I4)
Relationship of Customer Needs to Customer Insights	*Customer insights are the beginning of the process where you did the observation or whatever type of market research you undertake, and they've got lots of these data points, these statements and things and observations by the team, and they are then condensed into certain levels of needs.* (C5-I1)
	Kind of taking non-technical things and translating them into technical things. (C5-I3)
	I think it's in many ways very circular, it could be that the insight leads to the need, or it could be that the need leads to the insight, but they're both necessary to develop. What our surgeons actually need versus what we think they need. (C5-I4)

G.3 RQ1 Participant's Response to the Customer Need Definition from the SLR – CS5 Minerva

Customer Need Definition Broken down	Explanation	C5-I1	C5-I2	C5-I3	C5-I4	Supporting Quotes	Disconfirming Quotes
A statement crafted by the team	The innovation team analyse the market research data and interpret (crafted) this into a sentence/commentary that captures what the customer wants.	+	+	NM	NM	*Statement corrected by the team that reflects the customer's future breadth and value of the products use. Yes. OK.* (C5-I2).	
Reflects the customer's future	Though the customer need is interpreted by the team (reflect), the customer still owns the customer need. As such, the need can change if the market or environment changes for/by the customer (future).	+	+	NM	+	*I don't think the customer owns it, it's hard to say what the customer owns. Now, sorry, let me think on this for a minute. I guess I agree with that, it's dynamic, it can change. Ultimately, it's the innovation team that must analyse it, update, and reflect the changes, if they do change. So, I think it's the responsibility of the innovation team to kind of own the need.* (C5-I1).	
Benefit from and value of a product's use	What will the customer gain (value and benefit), and the job they can perform better (product's use)	+	-	NM	+	*Benefit and value of our products use. OK, I agree with the third one, but I still think that that higher level statement above, I feel it's missing the benefit and value of what we're offering.* (C5-I1).	*Benefit is I don't know that benefit, what's the benefit mean, like what is it benefiting the customer.* (C5-I2).

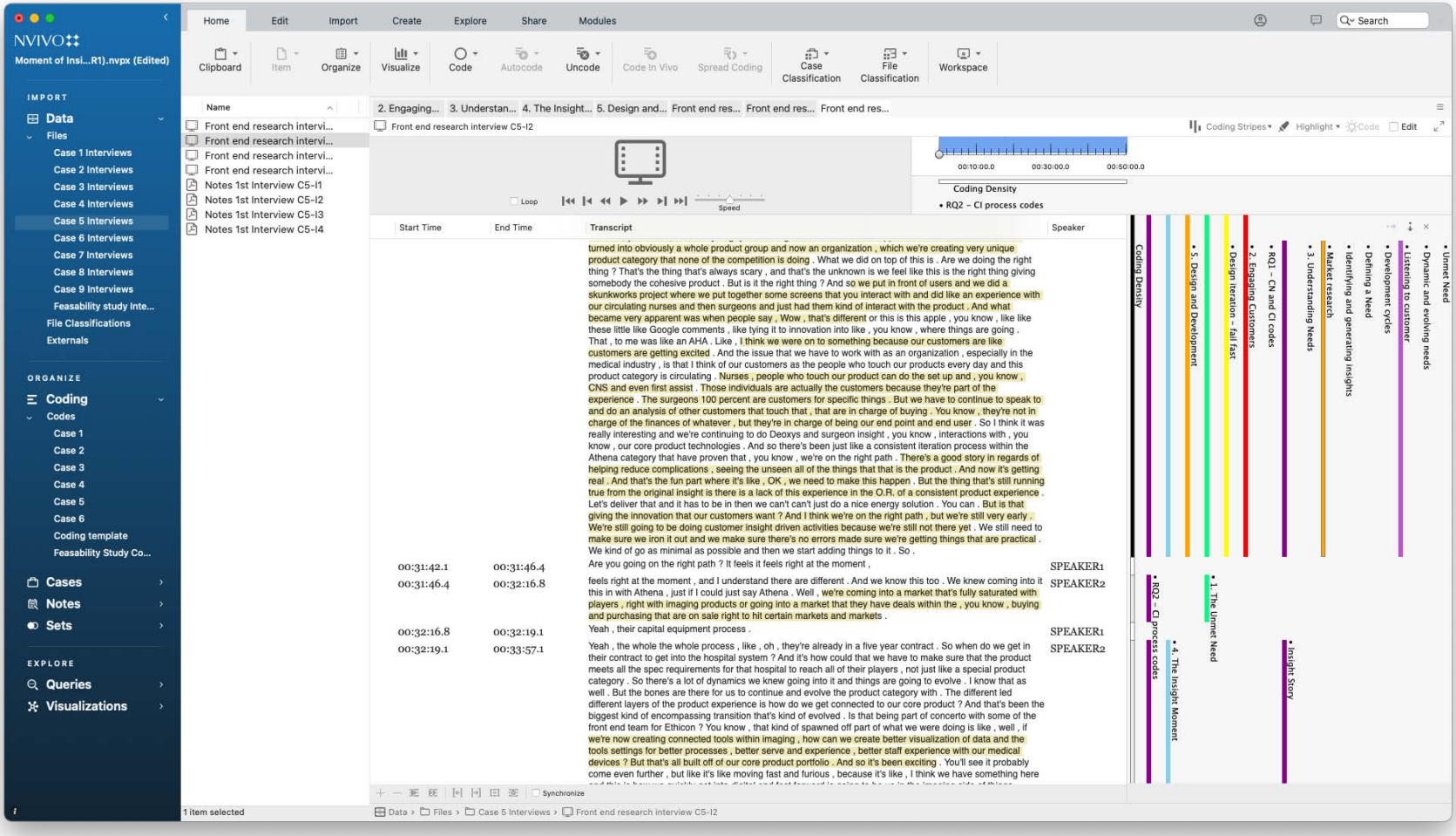
G.4 RQ1 Participant's Response to the Customer Insight Definition from the SLR – CS5 Minerva

Customer Insight Definition Broken down	Explanations	C5-I1	C5-I2	C5-I3	C5-I4	Supporting Quotes	Disconfirming Quotes
Expression of deep knowledge	The innovation team gain a unique interpretation and comprehension of the customer needs and market research data	+	+	NM	+	*It's digging a level deeper to actually understand the need versus just knowing what it is. You talk about the need and then it's through that conversation that you get to the insight.* (C5-I4)	
Actionable	Is practical and implementable	-	+	NM	+	*I think it's a good one. Actionable might be and may want to tweak that a little bit. What I see is practical and implementable because where I look at, you know, this taking in an idea is like, learning the unknown or exploring the unknown.* (C5-I4)	*If a customer said that a critical structure over there is really a risky part of my surgery, for example, and you see parts of a procedure it's not being stated as a solution, no solution was identified certainly nothing actionable.* (C5-I1)
Non-obvious, creative	Restructuring the problem and recombining data to create unexpected ideas	-	-	NM	NM		*Sometimes the simplest things are obvious So I maybe I would rework that because I always have that go with your gut or it's right in front of your face.* (C5-I2)
Solution		-	-	NM	NM		*Insight translates into a need, an unmet need. And then, you know ideation around what solutions to that are can cascade from that expression of deep knowledge.* (C5-I1)

G.5 RQ1 Participant's Response to the Relationship Between Customer Needs and Customer Insights – CS5 Minerva

Case Participant	Relationship	Sequence	Other Relationship	Representative Quotes by Participant
C5-I1	Not mentioned	Insight to need		*There could be many data points and we're collecting as many of these data points as we wish to collect then we do an internal analysis to then try to extract what we believe are the unmet needs.*
C5-I2	Not mentioned	Not mentioned		
C5-I3	Not mentioned	Insight to Need	NA	*Kind of taking non-technical things and translating them into technical things.*
C5-I4	Overlap	Insight to Need Need to Insight	Circular process	*I think it's in many ways very circular, it could be that the insight leads to the need, or it could be that the need leads to the insight.*

G.6 RQ2 Example Coding of Transcript Interview – CS5 Minerva



G.7 RQ2 Analysis: Second and First-order coding for the Insight Moment Process – CS5 Minerva

Second-Order Codes	First-Order Codes	Representative Quotes	Case Participant
Project Strategy	Innovation Type	*There are other technologies that are starting to be introduced into the clinical field that are bringing pieces of this together. This would certainly be on the forefront with those as a kind of pushing the boundaries of the surgical visualisation.*	C5-I1
	Market orientation	*Ultimate commercial driver for the project is actually not even so much in our laparoscopic business, it's actually in our robotics group.*	C5-I3
	Platform plan	*MGP was the multi-generational platform plan, so that is not here and now. I think because this is new and we want to get there, we want to get out there and get the actual product in the hands of our surgeons to understand what you know, what is the real MVP.*	C5-I4
	Team	*Let's see you guys come together and make this happen. And we did. And then that turned into obviously a whole product group and now an organization which we're creating very unique product category that none of the competition is doing.*	C5-I2
Understanding the Unmet Need	Market research	*I typically have done and gained insights from a customer from customers actually being in the field. We had plenty of very smart people doing the market dynamics of where the category can go*	C5-I2
	Project definition	*A laparoscopic visualisation video system that incorporates what I would call standard of care visualisation which is kind of like colour high-definition colour video with new imaging technologies that allow surgeons to detect critical structures that they would otherwise not be able to see and to localise, visualise and localise cancer intra operatively.*	C5-I1
	Unmet Need	*Medical imaging, you're noticing a market dynamic that's starting to shift from data and imaging is a big part of that. And there's a big need in regard to seeing the unseen.*	C5-I2
Engaging with Customers	Customer Experiences	*That's why we go back to our customers, our doctors, our customers, and the admins. But the people who are holistically interacting with all of our products with full experience are those staff members.*	C5-I2
	Customer involvement	*More often than not, those surgeons are key opinion leaders in the industry, very well regarded, highly esteemed, highly experienced folks. I understand why we formed those teams to help develop, to make sure we're building world class products.*	C5-I3

Second-Order Codes	First-Order Codes	Representative Quotes	Case Participant
	Listening to customer	*Not every surgeon agrees and right. You may nine out of ten surgeons may agree that this is an unmet need, but one out of ten does not.*	C5-I1
	VOC	*Our marketing team went out and did a tremendous amount of voice of the customer very early on.*	C5-I3
Understanding the Customer Needs	Benefits and values	*We're providing value here that we're not capturing because we think it's such an expectation that it doesn't have differentiated value.*	C5-I4
	Deep understanding of Underlying Motivations	*What we have learned is that there's also circulating nurses versus those that do everything right, you know, are coming in and their hands in the operating room.*	C5-I2
	Distilling the data	*Data and distilling it down into something that we can interpret, something that we can quantify and then something that we can then put into a product is a pretty intense effort, especially in a system like this that we're building from scratch.*	C5-I3
	Dynamic and evolving needs	*Our understanding or our interpretation of the need is evolving as we're learning more about the product and putting the early prototypes of the product in the hands of the customers.*	C5-I1
	Ethnography and observation	*Stanford Biodesign approach and you're immersing yourself and you're seeing things.*	C5-I
	Identifying needs	*The process was really just a group sitting down weekly, going through piece by piece and kind of clarifying understanding and then translating. We will go back to the customer and say, based on what we're finding here, here's some of our outputs.*	C5-I3
	Inability to meet the needs	*Sometimes we find that unfortunately, some things that we feel are high priority or the customer feels are our priority are things that we just can't deliver on, or we can deliver on in part. And then we have to go have that conversation.*	C5-I3
	Iterating the data	*There's a lot of questions that we're getting at each of those. If you want to say sort of increments, if you will getting to customer input requirements, then getting in to design input requirements based on all of this that's been done to date There's a lot of circular work whereby we're having to go back even to the C-level and kind of push on those thinking to those a little bit more and say, What is it that you really meant by this.*	C5-I3

Second-Order Codes	First-Order Codes	Representative Quotes	Case Participant
	Needs prioritisation	*What I love about working on this team is it is truly a partnership, and it is a give and take and it is a trade-off discussion, and it is mutual respect for both parties. There's no there's no head butting. We all want the same thing. We want to bring better technology to the customer.*	C5-I4
	Technology solution and technical language	*What we learned from that research is we actually need to offer a really simple solution until we understood more of what our competitors are doing and what our surgeons actually want in the wider market once they've used this type of product for a longer time.*	C5-I4
	Unsatisfied needs	*And so, and not only has it not fully delivered on the need it's created, but you also know, whether it's financial burden or workflow burden that just we couldn't get over the barrier, the red-faced test of an adaptability. But that remains a need. And it's not that we didn't put it in because we didn't believe it was a need or believe we knew enough about it There's just nothing today to deliver on it, and it's not such a priority.*	C5-I4
Discovering Customer Insights	Discovering Insights	*It's purely an observing process, observance go into clinical settings. Observing and watching the workflow, they're watching their problems that exist or they're asking questions about basic questions about why you did that in their lives. They're listening for or the people who are doing the process, things that might lead to that recognition that there is a this is a pain point in the process.*	C5-I1
	Identifying and generating insights	*Surgeon says, 'I can't ever find one or the one that's in my room is broken or it's got moved to another room'. And so, it felt like such a simplistic insight. But it matters, we're like, well, of course we would offer it like. Why wouldn't we but to them, it was like, yeah, if it's all going to be there and I can use that smoke back in every single case, every single laparoscopic surgery. Awesome.*	C5-I4
	Insight Story	*The point was that was an aha moment for us, where we gave them something new and different that they've never had before. And we thought it would be good for a certain use case, and they agreed it would be good for a use case. But all of a sudden, as clinical specialists, they started to see much more utility and they started to play back to us new use cases that they would want to use it for.*	C5-I1
	Start of insight	*Corporate sponsors created this kind of chartered group, very small charter product to figure out where it is this product category goes in this aha moment of, we have all of these devices that all sits on carts.*	C5-I2

Second-Order Codes	First-Order Codes	Representative Quotes	Case Participant
Iterative Design and Development	Design Compromises	*Big hot topic item is we know that the smaller the scope, we hear this from surgeons every day, there's less risk of herniation at those incision sites. So, we want to move in a direction of a smaller laparoscopic. But we also know that to deliver the technology, which requires a stereo scope and 3-D and we had to compromise on that.*	C5-I4
	Design iteration - fail fast	*Make sure we iron it out and we make sure there's no errors made sure we're getting things that are practical.*	C5-I2
	Development cycles	*And the key checkpoints that I've usually seen along the way is your first opportunity to really get hard, objective evidence. Challenge your design and your design outputs is your first round of confidence testing.*	C5-I3
	Prototyping	*Higher fidelity than just like a 3D print, but something that was had electronics inside wasn't an actual scope.*	C5-I2
	Usability	*We had working webcams in them that are hooked up to a USB, that go to a large display. And then on top of that we developed UI. On top of that, that works out like a head-ups live with the buttons on the scope. Something that gives you the perceived value of the experience.*	C5-I2

G.8 RQ2 Data Structure – CS5 Minerva

Code Name	References
RQ2 - CI process codes	196
Project Strategy	17
Innovation Type	3
Market orientation	5
Platform plan	4
Team	5
Understanding the Unmet Need	18
Market research	6
Project definition	2
Unmet Need	10
Engaging with Customers	28
Customer Experiences	6
Customer involvement	8
Listening to customer	9
VOC	5
Understanding the Customer Needs	44
Benefits and values	1
Deep understanding of Underlying Motivations	4
Distilling the data	2
Dynamic and evolving needs	10
Ethnography and observation	5
Identifying needs	12
Inability to meet the needs	1
Iterating the data	1
Needs prioritisation	4
Technology solution and technical language	3
Unsatisfied needs	1
Discovering Customer Insights	66
Discovering Insights	14
Identifying and generating insights	13
Insight Story	36
Start of insight	3
Ierative Design and Development	23
Design Comproimises	1

Code Name	References
Design iteration - fail fast	6
Development cycles	10
Prototyping	2
Usability	4
Blanks	0
Creativity and imaginative thinking	0
Deep understanding of customer's underlying motivations	0
Design - user, human-centred, empathic, thinking	0
Gestalt	0
Own words	0
Radical, incremental innovation	0
Transforming data into meaningful knowledge	0
Unarticulated, tacit, latent, unconscious	0

G.9 RQ2 Practices and Elements of Insight Moment Process – CS5 Minerva

Process Step	Input	Action	Output	Representative Quotes	Case Participant
Project Strategy	Multi-generational platform plan	Technology landscape search	Strategic direction	*MGP was the multi-generational platform plan, so that is not here and now. I know this is not an MVP, but this is pipeline. We have to keep thinking forward and keep garnering, you know, new information about those needs. But let's get a product to market too.*	C5-I1
	Strategic direction	Review clinical needs	Defined unmet clinical and business need	*Match between strategic product direction and an unmet need.*	C5-I4
				Target product profile provided information on the unmet need, business need, and market.	C5-D1
Understanding the Unmet Need	Defined unmet clinical and business need	Market research	Refined unmet clinical need	*Let's see you guys come together and make this happen and we did. And then that turned into obviously a whole product group and now an organisation, in which we're creating a very unique product category.*	C5-I2
	Refined unmet clinical need	Find customer groups	Identified Customers	*Nurses, people who touch our product can do the set up and, CNS and even first assist. Those individuals are actually the customers because they're part of the experience.*	C5-I2
	Identified Customers	Find customer groups	Identified additional Customers	*Majority of users that are maybe less skilled, less experienced and we see that feedback upon launch where they were having challenges or difficulty with various things.*	C5-I4
Engaging with Customers	Identified Customers	Gather market research	Market research data	*We do a lot of research, market research and voice of the customer.*	C5-I1

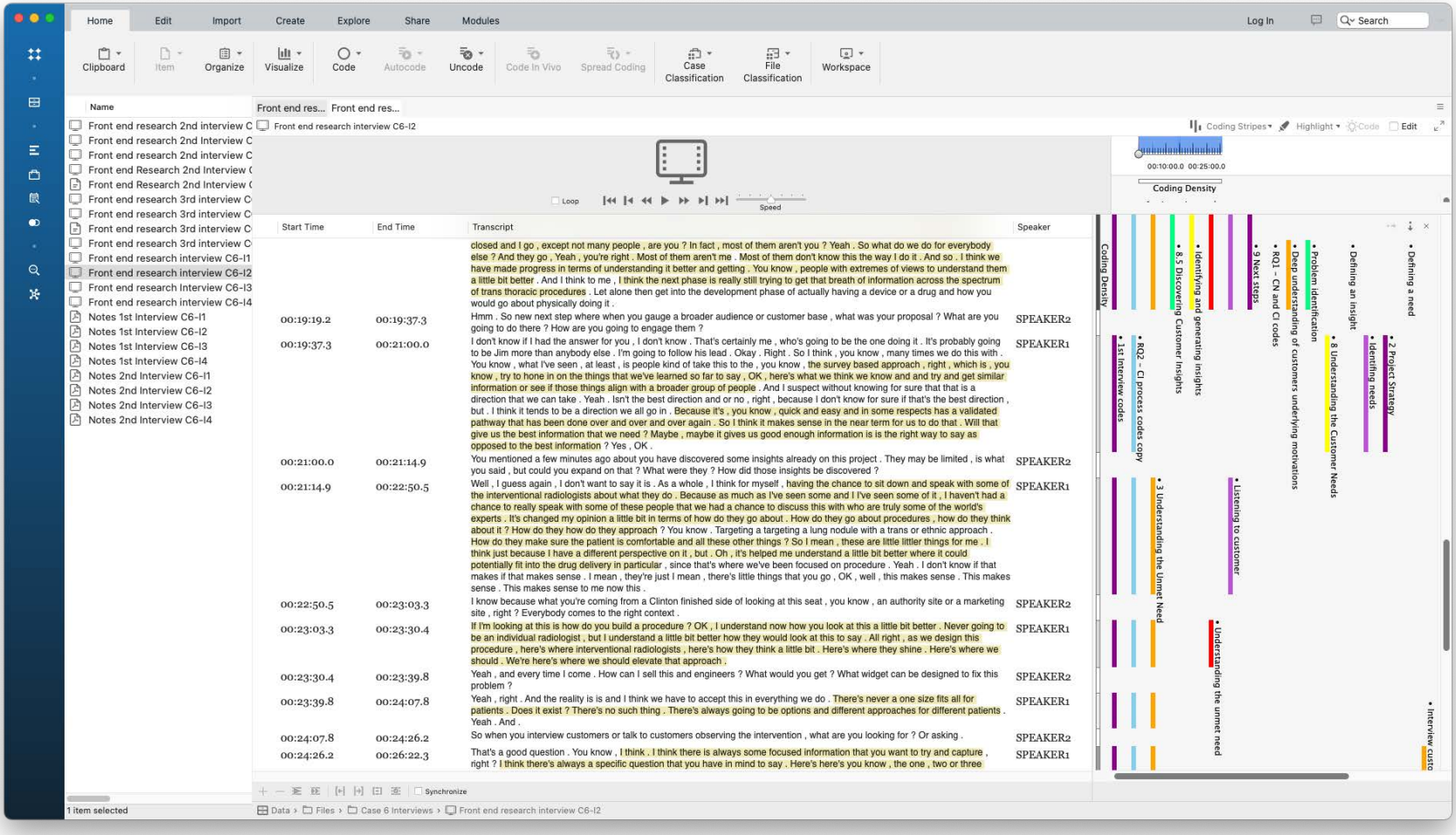
Process Step	Input	Action	Output	Representative Quotes	Case Participant
	Market research data	VOC	VOC statements	*Our marketing team went out and did a tremendous amount of voice of the customer very early on. Listening standpoint just to try to understand the customer more and more so that I'm helping to guide the project as best as possible, not to help make technical decisions, but just to have that vernacular of what we're after.*	C5-I3
	VOC statements	Simulated use	VOC report	*We're doing all of the development and customer needs and customer journey. So, going in front of surgeons and asking them, does this technology or this type of application is from a product experience need.*	
				Customer Input Requirements provided the customer needs from the VOC report.	C5-D2
Understanding the Customer Needs	VOC report	Interpretation of VOC	Identified needs	*Stanford Biodesign approach and you're immersing yourself and you're seeing things. It's not being stated as a solution, no solution was identified. Certainly nothing actionable you're looking for.*	C5-I1
	Identified needs	Engaging internal sources of need	Refined needs	*Very critical inputs actually come by way of non-traditional means, either by internal stakeholders that are maybe close to commercial applications or folks that experience that have experience with devices, maybe engineers who are on different project teams. Can actually land what in some cases becomes differentiating features that we deliver.*	C5-I3
	Identified needs	Learning through prototyping	Refined needs	*Our understanding or our interpretation of the need is evolving as we're learning more about the product and putting the early prototypes of the product in the hands of the customer.*	C5-I1
				Customer Input Requirements provided the customer needs from the VOC report.	C5-D2

Process Step	Input	Action	Output	Representative Quotes	Case Participant
	Refined needs	Translating the data into needs	Customer Input Requirements	*That process was really just a group sitting down weekly, going through piece by piece and kind of clarifying understanding and then translating.*	C5-I3
				Customer Input Requirements provided the customer needs from the VOC report.	C5-D2
	Refined needs	Iterating understanding	Customer Input Requirements	*There's a lot of questions that we're getting at each of those. If you want to say sort of two increments, getting to customer input requirements, then getting into design input requirements. There's a lot of circular work.*	C5-I3
	Refined needs	Distilling data	Customer Input Requirements	*Data and distilling it down into something that we can interpret, something that we can quantify and then something that we can then put into a product is a pretty intense effort.*	C5-I3
	Customer Input Requirements	Team design review	Prioritised l Customer Input Requirements	*We do the best that we can to prioritise them, both working with the customers and kind of based on our internal tacit knowledge.*	C5-I3
Discovering Customer Insights	Prioritised Customer Input Requirements	Observation Finding pain points	Design prototype	*Observing and watching the workflow, they're watching their problems that exist or they're asking questions about. basic questions about why did you do that in their lives? They're listening for or the people who are doing the process to things that might lead to that recognition that there is a this is a pain point in the process.*	C5-I1
	Design prototype	Design meeting	Discovered insights in other applications	*AHA moment was all the new ideas that they had that we hadn't even thought of. For example, they started to step in that they started to see the utility of this, wow, wouldn't it be great if we could use this to help us determine tumour margins. This led to more idea, we could put this on top of it.*	C5-I2

Process Step	Input	Action	Output	Representative Quotes	Case Participant
	Design prototype	Design meeting	Discovered insights	*It's an example where a technology, when you give a technology to a user, they find utility in it, possibly beyond what it was originally planned for. how creative human beings can be once they're given a tool may have been originally thought. Have learnings that challenge our original definition of the customer need.*	C5-I2
	Design prototype	Design meeting	Discovered insights and refined prototype	*I think we were on to something because our customers are like customers are getting excited.*	C5-I3
Iterative Design and Development	Prototype	Brainstorming idea	Refined prototype	*I think, once we start talking about something that's kind of cool and interesting and new to our R&D team and our design team and the wheels start turning and it's such great ideation. And what we learned from that research is we actually need to offer a really simple solution until we understood more of what our competitors are doing and what our surgeons actually want in the wider market once they've used this type of product for a longer time. And so, we don't want to complicate our design and complicate our timelines with some solution that we thought was better.*	C5-I4
	Prototype	Design meeting	Refined prototype	*We are doing a lot of customer insights in market research. And having them evaluate prototypes, but it's been more of kind of figuring out, for example, different handle designs for the laparoscope.*	C5-I1
	Prototype fidelity	Design meeting	Refined prototype	*We like to realise things as high fidelity as possible and get into our customers' hands.*	C5-I2
	Prototype fidelity	Design meeting	Refined prototype	*And the key checkpoints that I've usually seen along the way is your first opportunity to really get hard, objective all evidence or challenge to your design and put your design outputs is your first round of confidence testing.*	C5-I3

Appendix H – Data Supporting Case Study 6 Plexus

H.1 RQ2 Example Coding of Transcript Interview - CS6 Plexus



H.2 RQ2 Data Structure - CS6 Plexus

Code Name	References
RQ2 - CI process codes	**268**
1st Interview codes	143
Project Strategy	14
Front-end strategy	2
Level of understanding	2
Portfolio fit	1
Project background	6
Team involvement	3
Understanding the Unmet Need	74
Analogy for an insight	1
Asking questions	2
Benefits and values	3
Breadth of customers	3
Building understanding	1
Commercial considerations	3
Deep understanding of customers' underlying motivations	2
Ethnography and observation	7
Identifying the unmet need	1
Interview customers	6
Investigate the full customer experience	2
Listening to customer	10
Market research	2
Past experience	1
Problem identification	2
Procedure mapping	4
Project purpose	1
Transforming data into meaningful knowledge	2
Understanding the market	9
Understanding the unmet need	12
Technology Development	12
Market orientation	2
Technology mapping	3
Technology solution and technical language	6
Understanding the Customer Needs	19
Beginning of the project activity	1

Code Name	References
Identifying needs	12
Jobs to be done	1
Initial step in the process	1
Start to understand needs	2
Validating needs	2
Discovering Customer Insights	18
Identifying and generating insights	12
Insight realisation	4
Own words	1
Understanding the customers problems	1
Next steps	6
Blanks	0
Creativity and imaginative thinking	0
Customer involvement	0
Design - user, human-centred, empathic, thinking	0
Dynamic and evolving needs	0
Gestalt	0
Radical, incremental innovation	0
Unarticulated, tacit, latent, unsconcious	0
VOC	0
2nd Interview codes	72
Project Strategy	16
Business and technology questions	1
Expanding the team	5
Identifying new partners	1
Progress	5
Project engagement	2
Recap comment	2
Engaging with Customers	22
Analysing the data	4
Better appreciation	2
Deeper understanding of challenge	6
Ethnography study	5
Listening to the customer	1
Understanding the job to be done	2
Updated procedure map	2

Code Name	References
Iterative Design and Development	5
Lab experiments	1
Mock tumour board	3
Workshop internal	1
Understanding the Customer Needs	26
Prioritising unmet needs	7
Refining the needs statement	6
Refining the unmet clinical need	12
Validating the need statements	1
Next steps in research	3
3rd Interview codes	53
Discovering Customer Insights	4
Understanding the Customer Needs	36
Change in practice	1
Commerical value	1
Differing users	1
MVP	1
Problem solving	4
Process	2
Refining the needs	7
Showing benefit	1
Technical challenge	5
Understanding the needs	4
Unmet needs	5
Validating needs	4
Project Stategy	4
Market research	3
Mock tumour board review	1
Next steps	6
Needs to design requirements	1
Front-end experience	3
Front-end complexity	1
Front-end decision carried through	1
Internal differences in approach	1

H.3 RQ2 Practices and Elements of Insight Moment Process – CS6 Plexus

Process Step	Input	Action	Output	Representative Quotes	Case Participant
1st Interview					
Project Strategy	Strategic direction	Project strategy discussion	Defined project strategy	*We're still focusing on Monarch as kind of a cornerstone and as a flagship of our therapeutic access portfolio, but we are expanding beyond that.*	C6-I1
				The ultimate goal of that project to me is to say, how do we develop a transthoracic drug delivery device and procedure.	C6-I2
				I think the best thing I like about front-end is really kind of deciding the early strategy of projects is you really get that. Your kind of really get that ability to decide where things are going to go early on.	C6-I3
Understanding the Unmet Need	Project strategy	Ethnography (Observation, Interviews)	Defined Unmet Clinical Need	*What they were attempting to do and what unmet needs they had preventing them from kind of realising their vision.*	C6-I1
				Biodesign Background - Unmet needs and prioritised needs statements.	C6-D2
	Project strategy	Ethnography (Observation, Interviews)	Defined Unmet Clinical Need	*A better understanding of what it is that they do and what they think they can, or they can't do. And I think for everybody else is really just getting to that point of understanding what it really means more than just what you read.*	C6-I2

Process Step	Input	Action	Output	Representative Quotes	Case Participant
	Defined Unmet Clinical Need	Ethnography (Observation, Interviews)	Identified patient group	*Patients are too heterogeneous. There's always lots of variability, it becomes too hard to say, 'you're always going to use Tool X to treat problem one'. Just never happens. So, I think success here would to me clearly to actually have a solution that transthoracic works for, but maybe more so as to have a good understanding of which patients are best for this versus which patients are best for something else.*	C6-I2
	Defined Unmet Clinical Need	Literature search and review	Refined unmet Clinical Needs	*I do a lot of literature reviews, so just kind of reading up what's currently being done, what some of the other studies have done, including those insights as well as what we could have learned from those.*	C6-I3
	Defined Unmet Clinical Need	Ethnography (Observation, Interviews)	Identified clinician group	*It's teaching us that we have to approach each field in a different way to achieve the same outcome.*	C6-I4
	Refined unmet Clinical Needs	Ethnography (Observation, Interviews)	Procedure map	*Build up an understanding of how the key opinion leaders within that specialty address lung procedures.*	C6-I1
				We're at the point of mapping that out into an end to end procedure and going through the kind of importance and satisfaction and opportunity prioritisation exercise. Trying to understand what their current practice was, where they saw opportunities for improvement.	
	Refined unmet Clinical Needs	Ethnography (Observation, Interviews)	Procedure map	*I have some understanding of what the problems are, what the limitations are.*	C6-I2
				Transthoracic- Enabled Intratumoral Drug Delivery Unmet Needs.	C6-D1
	Procedure map	Risk analysis	Risk assessment	*Doing risk analysis based on procedure maps and figuring out. which of the steps of the procedures are going to be the highest risk that we think so far.*	C6-I3

Process Step	Input	Action	Output	Representative Quotes	Case Participant
	Procedure map	Task Analysis	Identified need in Needs List	*As you step along the procedure and the ones that are that need that are extremely important but are not particularly well met.*	C6-I1
Technology Development	Procedure map Risk Assessment	Technology landscape review	Technology Assessment	*Is there anything out there we're looking for or meet us halfway? Especially as we're looking to go into clinical trials by the end of next year, so a lot of things we wouldn't have time to develop a whole new product for.*	C6-I3
Understanding the Customer Needs	Procedure map	Needs Assessment	Identified need in Needs List	*Identify the steps of the procedure and then you identify the needs the customer needs associated with each step.*	C6-I1
	Procedure map Risk assessment Technology Assessment	Jobs Assessment	Prioritised needs in Needs List	*Then once you have all those laid out, you can kind of say, in terms of the outcomes of the procedure, the desired outcomes, how important are each of those jobs because some of them are going to be like absolutely critical and some will be maybe kind of nice to haves and everything in between.*	C6-I1
	Prioritised needs in Needs List	Consolidate Needs and craft Needs Statements	Need statement list Iteration	*We're just at the point where we're starting to consolidate our need statements.*	C6-I1
	Need statement list Iteration	Needs Assessment with weighting	Validated and prioritising Need statement list	*Really understanding if the needs that we've identified are the true needs that we need to be going after, so kind of doing like a weighted assessment of them, the ranking of them.*	C6-I3
				So that's where you would go about explaining to them how you came about that in statement, so showing them all of the different processes that got there. So, it could have been that customer that you're validating with.	
				Biodesign Background - Unmet needs and prioritised needs statements.	C6-D2

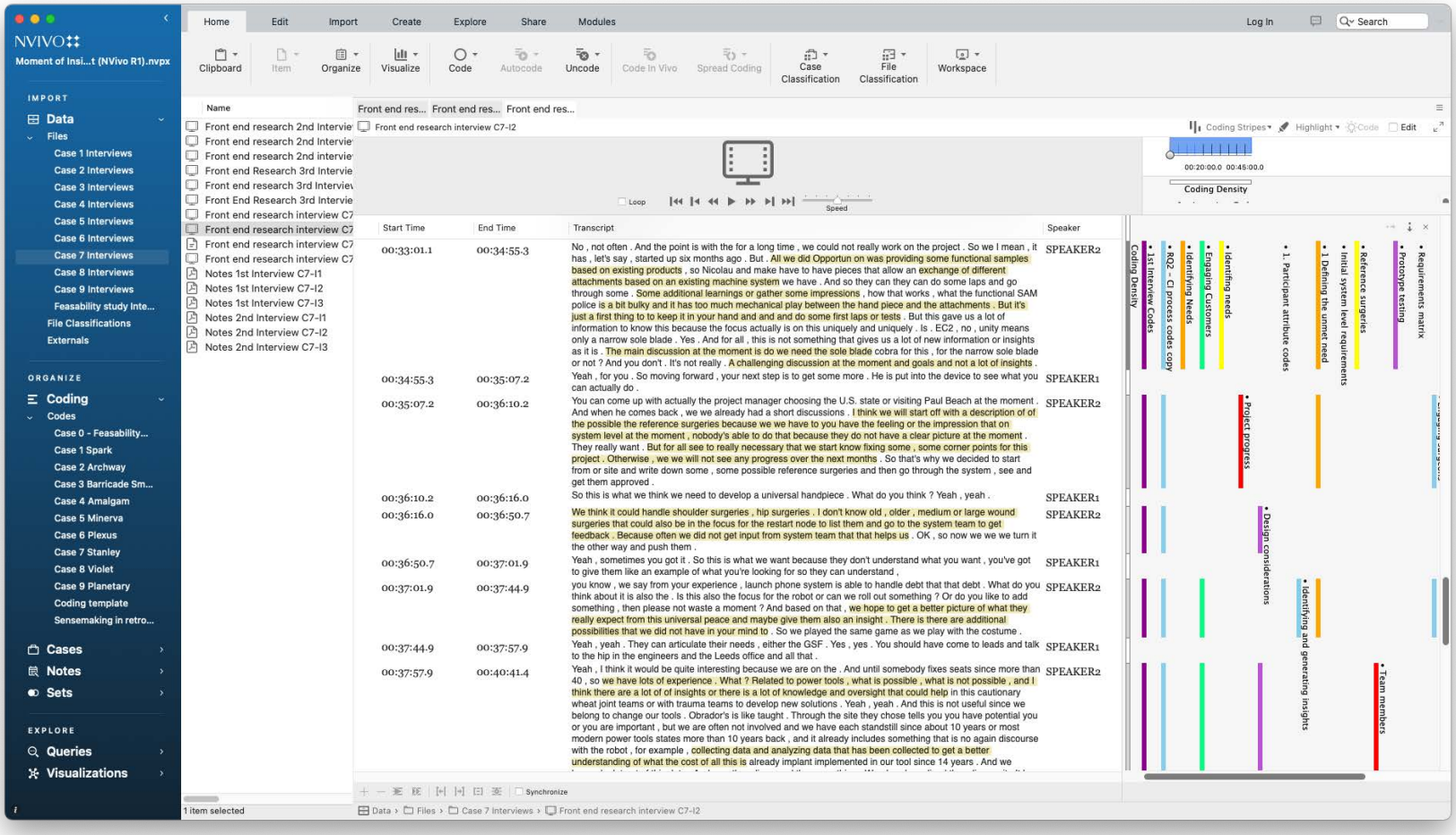
Process Step	Input	Action	Output	Representative Quotes	Case Participant
Discovering Customer Insights	Unmet Clinical Needs	Interviews Understanding the clinical attitude to the problem	Insight discovered	*When you talk to radiologists about that, their eyes glaze over and like, yep, not interested. It's my perspective was a little different because I was listening in on a lot of the conversations. And so, I had the opportunity to sort of like slowly to arrive at those insights. There was no eureka moment.*	C6-I1
	Insight discovered	Insight assessment	Insights workflow Identified need in Needs List	*And then the five people was more of a workshop where we took all the insights from the interviews and then laid it out in workflow.*	C6-I4
2nd Interview					
Project Strategy	Need statement list Iteration	Technology landscape review	Technology landscape	*Any specific technologies that might address some of the priority needs that were identified. We've done a couple of kind of technical partner visits.*	C6-I1
	Projects Strategy	Budget review	Prioritised scope	*We're now having to prioritise versus being able to at least have a lot of things to look at and explore.*	C6-I4
Engaging with Customers	Need statement list Iteration	Ethnography study	Study reports	*I am running an ethnography study with pharmacists and biosafety officer. I've been getting live reports at the end of each week as we get the interviews back.*	C6-I3
	Need statement list Iteration	Ethnography study	Study reports	*I think because we've already started doing that initial analysis like each week of the information, because we've been doing roughly like ten users each week for interviews.*	C6-I3
	Need statement list Iteration	Ethnography study	Study reports	*It's good for us to be aware of risk and insights that we can plan for.*	C6-I3
	Study reports	Analysis	Customer need statement list Iteration Procedure Map Iteration	*It's a combination of a lot of conversations with experts and forward thinkers in the field. A lot of work understanding and mapping out the procedural pathways.*	C6-I4

Process Step	Input	Action	Output	Representative Quotes	Case Participant
Iterative Design and Development	Procedure Map Iteration	Review cases	Procedure Map	*What I've been able to do is get access to a bunch of images in just a publicly available imaging sort of database with the goal of presenting the typical patient that we would consider for our indication to the whole team to be able to look at the images together to say, when we're talking about therapeutic delivery of a drug for these patients, what are the pros and the cons to each different approach that makes sense.*	C6-I2
	Procedure Map Iteration	Reviewing the procedure	Procedure Map iteration	*We had a fun workshop where it was just two hours talking about the procedure.*	C6-I3
	Need statement list Iteration	Invitro (Cadaver) lab	Lab report	*Yesterday we were just in the cadaveric lab where we were looking at injection systems and how they inject into tumours and what happened like that scanning in and seeing how things leak. And so, we have been doing some of those Real-Time injection kinds of experiences to see, you know, the viscosity, the liquid, all kinds of things that are associated with some of the technical pieces. And what will the implications be?*	C6-I4
Understanding the Customer Needs	Need statement list	Needs assessment refinement	Need statement list iteration	*We had those meetings and a whole bunch of needs went away because there were much simpler.* *We were able to get to our top ten was we created a value calculation where we talked about the cost of the problem, how many patients it might impact and what, how and what is the likelihood of success. So, it is a very crude calculation. And then we got to a dollar amount.*	C6-I4
	Need statement list	Needs assessment refinement	Need statement list iteration	*We wrote a whole bunch. I think we were at 50 and then we refined them. And then as we were tightening up the need statements with the help of our Biodesign consultant.*	C6-I4
3rd Interview					

Process Step	Input	Action	Output	Representative Quotes	Case Participant
Discovering Customer Insights	Unmet Clinical Needs	Interviews	Insight discovered	*Like just trying to like put that level of flexibility, and it felt like it was adding more risk than it was actually solving problems just because there was no, you know, similarities or consistency across a lot of these countries.*	C6-I3
Understanding the Customer Needs	Need statement list	Biodesign process	Refined the need statement list	*We went through the Biodesign process. It wasn't pure like from beginning to end because we had tons of insights and understanding. But then we landed onto 200 and funnelled them down to 18 top unmet needs.*	C6-I4
	Refined the need statement list		Identified MVP	*We're going for a minimally viable product. But the project is only addressing about half of the 18.*	C6-I4
	Refined the need statement list	Gate A actions	Move into Gate B	*And now it's instigated a very specific project. And during that project, that's when we're going to get more understanding of what needs it addresses.*	C6-I4
	Refined the need statement list	Gate A actions	Move into Gate B	*So, we're actually moving in less from a research point of view and more into development.*	C6-I3
				Cadence stage-gate guidance v11.	CX-D1
Project Strategy	Prioritised scope	Budget review	Prioritised scope	*And now it's it's instigated a very specific project. And during that project, that's when we're going to get more understanding of what needs we did address.*	C6-I3

Appendix I – Data Supporting Case Study 7 Stanley

I.1 RQ2 Example Coding of Transcript Interview - CS7 Stanley



I.2 RQ2 Data Structure - CS7 Stanley

Code Name	References
RQ2 - CI process codes copy	133
1st Interview Codes	73
Project Strategy and Understanding the unmet need	6
Engaging surgeons	2
Reference surgeries	3
Technology Development	9
Performance improvements	1
Structured approach	1
Team members	2
Technical challenges	4
Technology solution and technical language	1
Engaging with Customers	22
Ethnography and observation	1
Identifying and generating insights	7
Listening to customer	2
Market research	3
Prototype testing	7
VOC	1
Understanding the Customer Needs	24
Identifying needs	13
Initial system level requirements	5
Requirements matrix	4
Validating the needs	2
Project progress	12
Next steps	3
Blanks	0
Benefits and values	0
Creativity and imaginative thinking	0
Customer involvement	0
Deep understanding of customers underlying motivations	0
Design - user, human-centred, empathic, thinking	0
Dynamic and evolving needs	0
Gestalt	0
Market orientation	0

Code Name	References
Own words	0
Radical, incremental innovation	0
Transforming data into meaningful knowledge	0
Unarticulated, tacit, latent, unconscious	0
2nd Interview codes	51
Project Status	6
Next design steps	3
Project disruption	2
Project Strategy	3
Reference operations - expanded needs	2
Team	4
Engaging with Customers	45
Design considerations	5
Design requirements	1
Prototype design feedback	17
3rd Interview codes	9

I.3 RQ2 Practices and Elements of Insight Moment Process – CS7 Stanley

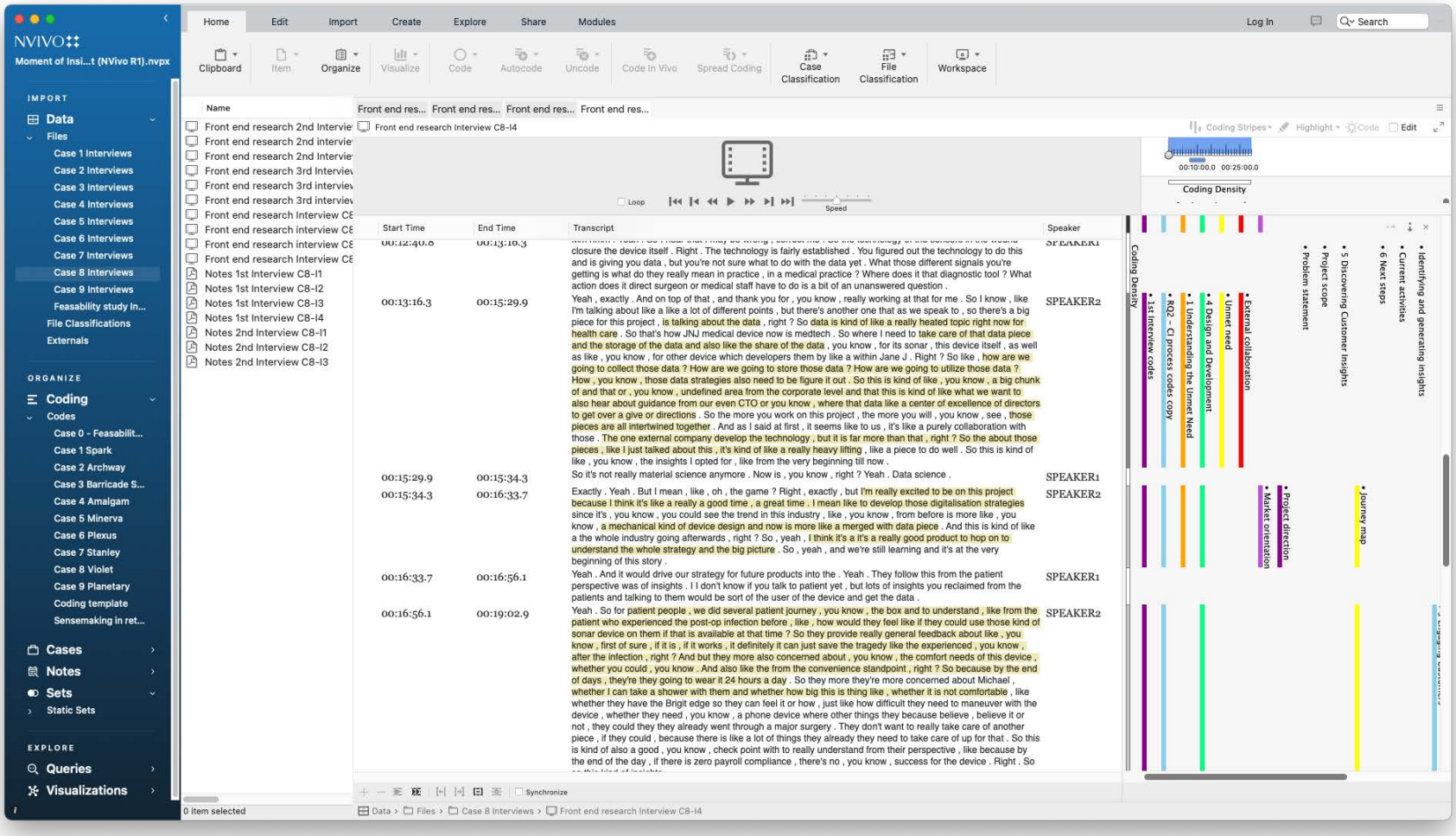
Process Step	Input	Action	Output	Representative Quotes	Case Participant
1st Interview					
Project Strategy and Understanding the Unmet need	Strategic direction	Input from other teams	Defined unmet need	*Create a robot to do total knee surgeries, it is a new approach that's based on what they traditionally did to it with a hand tool. And it improves the accuracy. It is a new approach for them, it allows to have a better solution a better overall solution at the end for the patient.*	C7-I2
				Unmet need captured in the Target Product Profile.	C7-D1
Technology Development	Unmet need	Design analyses	Feasibility Concepts	*We are already thinking about how we can solve attachment coupling.*	C7-I2
				A double trigger for which we reverse or forward and design a gear that gives us more than one speed for sawing, reaming, and drilling.	C7-I2
				I like structured approaches. This is what they often miss, or they really like it because it gives you a clear picture at the beginning.	C7-I1
Engaging with Customers	Review design concepts	Surgeon design meeting	Improved design concept	*Can get some new insights if I discuss with him about possible solutions so that there is also an element on the other side that we can get customer insights. Also, the customer can at some point realise, hey there could be a better solution for what I do.*	C7-I2
				The next steps are to test the product, we have a much broader base and more international.	C7-I3
				The intent was to get a first idea what they expect on system level regarding functionality and to define functionality.	C7-I2

Process Step	Input	Action	Output	Representative Quotes	Case Participant
Understanding the Customer Needs	Improved design concept	Internal design meetings	Reference surgeries	*We are talking to all these platform teams and try to find out in what surgeries they plan to do. And what is special for these surgeries or what kind of tools they use for these surgeries.*	C7-I1
				Customer need and user groups captured in the Target Product Profile.	C7-D1
	Reference surgeries Feedback on prototype	Internal design meetings	Requirements metrics Refined prototype	*We try to do in the next couple of weeks is to put together what we have, what you already have and what we already know regarding customer needs.*	C7-I1
2nd Interview					
Project Strategy					
Engaging with Customers	Refined prototype	Surgeon design meeting	New needs	*Voice of the customer event in Boston. We covered in total 14 surgeons. We are still analysing everything.*	C7-I3
	Questionnaire	Survey	Business case and strategy	*Individual questionnaires so that we could have the feedback, all the surgeries individually on many topics, and you would say there are more than 30 questions.*	C7-I3
	Refined prototype	Surgeon design meeting	Design feedback	*And then some question on the trigger was quite important. Yeah, I'll drag the trigger of a universal design prototype. Overall. And then all the requirements, they know that trigger is not very good.*	C7-I3
	Refined prototype	Surgeon design meeting	Refined prototype	*SLA model we showed in the lab in Boston. people liked the way trigger, and they identified the same, the same improvements that we already saw when we when we got reports here. there were no surprises.*	C7-I2

Process Step	Input	Action	Output	Representative Quotes	Case Participant
Project Strategy	Business case and strategy	Business review	Project continues	They talk with the project at the moment , because it's not that clear if we can continue with the project because of the budget restriction.	
3rd Interview					
	Business case and strategy	Business review	Defined project strategy - on hold	*It's really on hold at the moment.* *The business case was so far too much dependent on the unique project.* *Bit of lack of ownership of in the marketing department for who owns the with cross products business case.*	C7-I3

Appendix J – Data Supporting Case Study 8 Violet

J.1 RQ2 Example Coding of Transcript Interview – CS8 Violet



J.2 RQ2 Data Structure - CS8 Violet

Code Name	References
RQ2 - CI process codes copy	288
1st Interview codes	136
Project Strategy	15
Early landscape search	1
Market orientation	3
Project direction	11
Understanding the Unmet Need	42
Market research	5
Benefits and values	3
Identifying needs	4
Unmet need	25
Value of data	5
Engaging with Customers	12
Customer involvement	2
Early meeting with customers	5
Killer questions	2
Listening to customer	3
Design and Development	37
Design aspects	7
Development activities	6
External collaboration	7
Journey map	3
MVP	1
Problem statement	4
Technology solution and technical language	9
Discovering Customer Insights	23
Brainstorming	1
Customer definition	4
Customer insight	6
Identifying and generating insights	5
Insight story	7
Next steps	7
Current activities	2
Project scope	4

Code Name		References
	Project status	1
	VOC	4
Blanks		0
	Creativity and imaginative thinking	0
	Deep understanding of customers' underlying motivations	0
	Design - user, human-centred, empathic, thinking	0
	Dynamic and evolving needs	0
	Ethnography and observation	0
	Gestalt	0
	Own words	0
	Radical, incremental innovation	0
	Transforming data into meaningful knowledge	0
	Unarticulated, tacit, latent, unconscious	0
2nd Interview codes		86
Project Strategy		14
	Funding model	8
	Future insight	2
	Market change	3
	MVP	1
Engaging with Customers		51
	Agency market research	5
	Clinical study done	1
	Discovered insights	14
	First VOC study	17
	Prototyping	1
	Understanding the customer and value	6
Next steps		21
	Next step - clinical study	13
	Change in hospital and patient practice	4
	Clinical study outcome	1
	Next step design and human factors	5
	Second VOC study	3
3rd Interview codes		66
Project Strategy		25
	Cadence progress	4
	Creating the TPP	2

Code Name		References
	Product reuse	1
	Project funding and agreement	10
	Unmet need	1
	Value consideration	6
Iterative Design and Development		18
	Data concerns	6
	Finding the new users	3
	Future design considerations	5
	Understanding the product use decisions	3
Planned clinical study		23
	Clinical study	10
	Design for clinical study	9
Next steps		4

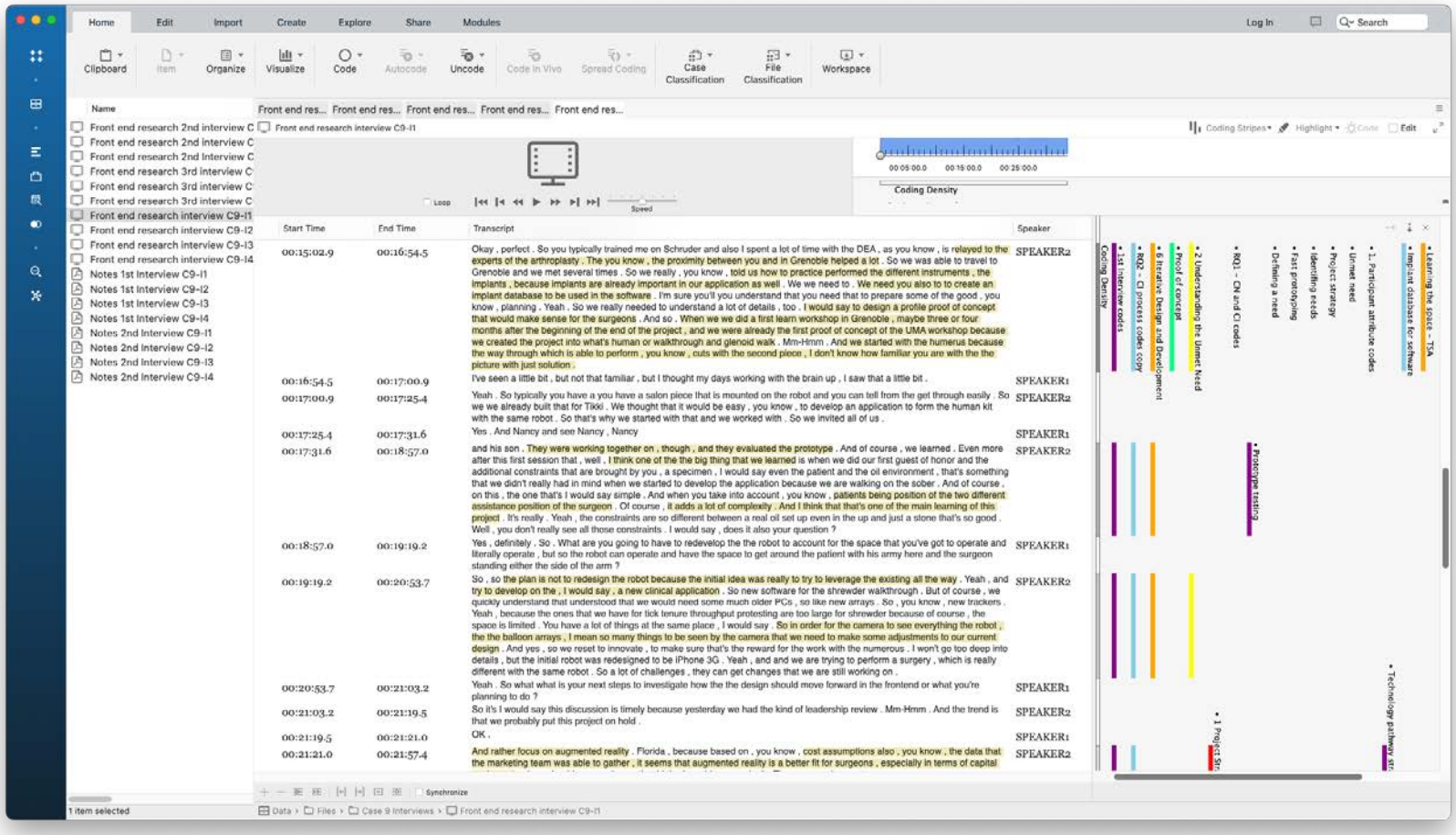
J.3 RQ2 Practices and Elements of Insight Moment Process - CS8 Violet

Process Step	Input	Action	Output	Representative Quotes	Case Participant
1st Interview					
Project Strategy	Strategic direction	Internal surgeon interviews	Defined unmet need	*We have already actually conducted a what we normally call, an in-house vehicle, see where we tapped into those who have an M.D. degree or surgical background within the company.*	C8-I3
Understanding the Unmet Need	Unmet need	VOC	Clinical Value Purchase Influencer Exploratory	*We first have to demonstrate that we have a proposition that generates clinical value.*	C8-I3 C8-D2
Engaging with Customers	Clinical Value	VOC with surgeons	Refined Unmet Need	*15 different surgeons that were internal we spoke with them about how they detect a surgical site infection.* Unmet needs VOC.	C8-I1 C8-D1
Iterative Design and Development	Refined Unmet Need	Technology landscape search	Established sensor technology Prototype design	*We started to work on kind of triangulating these three sensor types to then have more predictive potential for assisted detection.*	C8-I3
	Refined Unmet Need	VOC with surgeons	Journey map	*We need to build the journey map from the patient perspective and the physician's perspective.*	C8-I4
Discovering Customer Insights	Refined Unmet Need	VOC with surgeons	Discovered customer insights	*Go and talk to Dr. So-and-so down the hall. He has a problem.*	C8-I1
	Refined Unmet Need	VOC with surgeons	Discovered customer insights	*How can this data be used beyond the medical surgical application. In other words, if I, as the surgeon elects not to do anything based on the data because that is my medical opinion and then later something happens. What are the legal implications, ramifications of my decision.*	C8-I1

Process Step	Input	Action	Output	Representative Quotes	Case Participant
	Refined Unmet Need	VOC with surgeons C8-I3	Discovered customer insights	*That too was a little bit eye-opening, at least for me, because again. You know, wouldn't you want to know anyway? You know, even if it's good news or if there's no, you know, need for an intervention.*	C8-I1
2nd Interview					
Engaging with Customers	Prototype design Discovered customer insights	Preclinical studies	Preclinical studies outcome Prototype design	*Basically, successfully completed its first phase and by successfully, I mean, we have concluded two preclinical studies which have generated favourable data.*	
Project Strategy	Prototype design	Testing assumptions	Business model	*Also, it has to have a good financial case to be adopted. So, what is the pricing? So, we had preliminary pricing down pricing research done.*	C8-I3
	Business model	Project review	Project Budget	*Projects used to run really, really fast and in the old model because they we want you to work on that product. Go do it, here's the money and here's the account Go, just go do it. And people will do that. And now it's you got to, I think the approach of being so conservative and worried that money is going to be thrown away.*	C8-I2
3rd Interview					
Project Strategy	Business model	Project review	Project Budget		
Iterative Design and Development	Preclinical studies outcome	Understand the prototype feedback	Design iteration Killer Questions	*With the use of the product and having it be digitally connected, it may be a different go to market model.*	C8-I3
	Design iteration Killer Questions	Design and development	Clinical study proposal and final design prototype	*Hopefully beyond that point right after the favourable clinical that we're hopefully going to have, there's going to still be a lot of design that's going to have to happen and that we're going to have to figure out to get to a something that looks like a commercially viable product.*	C8-I1

Appendix K – Data Supporting Case Study 9 Planetary

K.1 RQ2 Example Coding of Transcript Interview - CS9 Planetary



K.2 RQ2 Data Structure - CS9 Planetary

Code Name	References
RQ2 - CI process codes	299
1st Interview codes	132
Project Strategy	42
Business case	6
Business challenges	12
Market orientation	2
Project strategy	9
Teams	1
Technology pathway strategy	12
Understanding the Unmet Need	24
Benefits and values	2
Customer involvement	1
Deep understanding of customers underlying motivations	1
Learning the space	3
Product mapping activity	7
Understanding the opportunity	2
Unmet need	8
Technology Development	46
Design considerations	7
Different solutions to technical challenge	6
Fast prototyping	1
Identifying needs	5
Implant database for software	1
Proof of concept	16
Prototype testing	6
Technology solution and technical language	3
Technology upgrade challenges	1
Engaging with Customers	7
Listening to customer	4
VOC	3
Discovering Customer Insights	6
Next step	7
Blanks	0

Code Name	References
Creativity and imaginative thinking	0
Design - user, human-centred, empathic, thinking	0
Dynamic and evolving needs	0
Ethnography and observation	0
Gestalt	0
Market research	0
Own words	0
Radical, incremental innovation	0
Transforming data into meaningful knowledge	0
Unarticulated, tacit, latent, unconscious	0
2nd Interview codes	77
Engaging with Customers	23
Prototype testing	5
Surgeon design meeting	9
VOC meeting	3
VOC meeting 2	6
Next steps	3
Planned VOC testing	2
Project progress	2
Iterative design and development	13
Design function changes	3
Design status	6
Elimination of technical challenges	2
Iteratve improvements	2
Project Strategy	38
Business case	10
New design pathway	6
Product road map	10
Project status	3
Team changes	2
Third party	4
Unmet need	3
3rd Interview codes	90
Iterative Design and Development	30
Design feedback	10
Design functions	4

Code Name		References
	Development steps	2
	Team interaction	1
	Technical challenges	8
	Understand MVP	5
Engaging with Customers		20
	Design meetings	11
	Prototype testing	3
	Surgeon design team	6
Project Strategy		30
	Business decision on project stategy	14
	Project status	8
	Roadmap	3
	Scope reduction	5
Next steps		10

K.3 RQ2 Practices and Elements of Insight Moment Process - CS9 Planetary

Process Step	Input	Action	Output	Representative Quotes	Case Participant
1st Interviews					
Project Strategy	Strategic Direction	Build business case	Business Case Target Product Profile	*Sometimes the tension between building the proof of concept and building the business case, they have to go hand-in-hand because you don't know what the solution will be to build the case at the costs like you.*	C9-I1
	Business Case Target Product Profile	Understand the business needs and the market opportunity	Defined unmet Need	*TPP, like the early the very early sections of the TPP, where you understand the business needs and the market opportunity.*	C9-I2
				TPP - The extremity joint replacement market is an attractive space, with shoulder reconstruction growing the fastest.	C9-D1
	Business Case Target Product Profile	IP search	Defined unmet Need	*I would say some very early deliverables from like an IP review perspective, a freedom to operate perspective.*	C9-I2
Understading the Unmet Need	Defined unmet Need	VOC study	Refined unmet need	*Some of the thinking has evolved a little bit around in which aspects are they're going to find value.*	C9-I3
				TPP - The VOC identified pain point opportunities	C9-D1
				I think the realisation going back to clinically meaningful error with robotics and some of this is probably driven by us using that robot.	C9-I4
				Really focused on the unmet need instead of the solution because it tends to find surgeons here or see something and they think about something similar.	C9-I4

Process Step	Input	Action	Output	Representative Quotes	Case Participant
	Defined unmet Need	Literature review	Refined unmet need	*We started talking about some literature that's come out recently that shows short stems and stem cells might suffer from some alignment issues, and that kind of drove a conversation with the surgeons.*	C9-I3
Technology Development	Refined unmet need	Technology risks	Back-up technology solution	*We actually already had a like a backup plan in progress, like a little side project on one of these handheld robots.*	C9-I2
				Front-end feasibility process.	C9-D2
	Refined unmet need	Technology risks	Back-up technology solution	*And so, we're looking to use some existing commercially available headsets to prove out the workflow.*	C9-I3
	Refined unmet need	Competitive technology search	Back-up technology solution	*I really try to be a kind of expert of the competitive systems to try to understand what could work well, what is not working well and ask some surgeons.*	C9-I1
	Refined unmet need	Development activities	Proof of concept (functional prototype)	*I think the developer process will take as long as that takes, but we need to have sort of something we can quickly play with . It's not doesn't need to be production ready, something that we can get through to get to the learnings around going back to the how to align a plane to a plane from a usability standpoint.*	C9-I3
	Refined unmet need	Development activities	Proof of concept (functional prototype)	*We developed a proof of concept in less than one year.*	C9-I1
	Proof of concept Establish Surgical workflow	Draft RTM	List of user needs	*We drafted an RTM as well to trace the user needs some design inputs as well.*	C9-I1

Process Step	Input	Action	Output	Representative Quotes	Case Participant
Engaging with Customers	Proof of concept	Surgeon design meeting	Refined prototype Technology issues	*We use the proof of concept that we developed, and we have a lot of questions about how different it is from our current practice. And is there something in what we developed that would be a major change for them? And is it acceptable or not acceptable.*	C9-I1
	Proof of concept	Surgeon design meeting	Refined prototype	*So, what we're trying to confirm right now is we have a proof of concept on the workflow and execution modes of how the surgeon would want to interact with any navigation platform on the steps of the procedure that are difficult for them.*	C9-I4
	Refined prototype List of user needs	Surgeon design meeting	Validated user needs	*If you were able to visualise this, regardless of how you want to do that, that would meet your unmet need. So, we're validating the unmet needs in the clinical workflow.*	C9-I4
	Refined unmet need	VOC study	Establish Surgical workflow	*We're doing a series of VOC questions and just talking through the workflows.* *Where do you see value in the workflows? what are the most important steps for you to navigate? And it wasn't a simple question answer.*	C9-I3
Discovering Customer Insights	Refined unmet need	Conversation with Surgeons	Customer Insight discovered	*That kind of drove a conversation with the surgeons about what happens, is that going to be a bigger problem in reverse where you're going to have significant moment arms drive implant loosening potentially. And then it's like sort of realising, wait a minute, we're not perfect now. And that's kind of where it came from. So not in the lab, but it was over just basically in a phone call or conversation.*	C9-I3
2nd Interviews					

Process Step	Input	Action	Output	Representative Quotes	Case Participant
Engaging with Customers	Iterative prototype design	Cadaver lab User feedback	Iterative prototype design	*We're able to test on cadavers as well. And it was pretty successful at this with the development team were able to provide very good feedback and try to implement new things, improvements.*	C9-I1
	Iterative prototype design	VOC	Decision on technology pathway	*Late June, we had a trip to Madrid for the voice of the customer Summit. And at that meeting, it kind of reaffirmed generally our approach, which we could have seen with the new robot in particular, that it wasn't really suited for shoulder. And then, when given an option of whether it be a robot or augmented reality headset-based navigation, that by and large felt that the navigation via the headset provided more value than the robot.* *We've done a bunch of VOC in the last four months.*	C9-I3
	Iterative prototype design	VOC	Decision on technology pathway	*I'm now seeing that if I had a robotic assist of some sort that really geofence to prevent me from making mistakes, not just informing me about my mistakes, but actually prevented me from them and kept me on target better, maybe that would actually make me even better. So, I think they're going to have to get there once they tried that headset on, they appreciate it more.*	C9-I3
	Iterative prototype design	VOC	Iterative prototype design. Storyboarding	*So how do we display the information, we're trying to build the overall storyboard for what we want the user experience to be.*	C9-I3
	Iterative prototype design	VOC	MVP	*We are really trying to understand the MVP to be able to go first because of course, our leaders would like us to go faster.*	C9-I3
Iterative Design and Development	Refined prototype	Development activities	Iterative prototype design	*It's iterative improvements, lessons learned from these feedbacks who implement those. There are some additional modules related to tying into headsets.*	C9-I1

Process Step	Input	Action	Output	Representative Quotes	Case Participant
	Refined prototype	Development activities	Iterative prototype design	*I'd say at a high level, it's really been an early concept refinement for the tissue sparing, but for the robotic AR discussion, it's been sort of rapid iteration and exploration of new technology.*	C9-I3
Project Strategy	Business case Technology issues	Strategy meeting	Robot application on hold TPP	*The robotic application was on hold because the focus right now is more on augmented reality.* *They don't perform a lot of surgeries a year, and the cost of the robot is pretty prohibitive.*	C9-I1
	AR platform	Technology partnership meeting	Technology pathway	*That's kind of been the theme of this year, in the absence of being able to move forward with the partner, what can we do? Like what can add value right now.*	C9-I2
3rd Inteviews					
Iterative design and development	Scope reduction (unmet need and functons)	Development activities	Reduced scope prototype	*We still have some technical issues that we would like to solve, some improvements that we would like to do, for example, we are not happy yet with the accuracy that we can achieve.*	C9-I3
	Reduced scope prototype	Surgeon design meeting	Iterative prototype design	*We only started programming it in August, so by December it was getting much better and we had the lab again on Friday.*	C9-I3
Project Strategy	Target Product Profile Prototype	Strategy meeting	Scope reduction (unmet need and functons)	*To try to reduce the scope, we'll probably try to focus first on the glenoid, which is the main unmet need.* *A lot of different options that we implemented in the prototype that we need to figure out if we will keep them in the product.*	
Engaging with Customers	Reduced scope prototype	Surgeon design meeting	Iterative prototype design	*We had a lab last week with design, so that's the first time that they that they've seen the prototype.*	C9-I1

Appendix L – Case Study Data Collection Summary

L.1 Retrospective Case Study Data Collection Summary

Case Participant	PhD Project Code	Case Type	Role, Job Title	Country	Interview Date	Interview time length (mins:sec)
C1-I1	Spark	Retrospective	Industrial Designer	US	Wednesday, 5 January 2022	61.09
C1-I2	Spark	Retrospective	Marketing Director	UK	Thursday, 6 January 2022	36.32
C1-I3	Spark	Retrospective	Lead Engineer	UK	Friday, 7 January 2022	38.59
C1-I4	Spark	Retrospective	Engineer	US	Friday, 7 January 2022	44.44
					Average	45.11
					Total	180.44
C2-I1	Archway	Retrospective	Principal Design Engineer	US	Tuesday, 25 January 2022	50.16
C2-I2	Archway	Retrospective	Project Director	US	Thursday, 27 January 2022	53.19
C2-I3	Archway	Retrospective	Marketing Director	US	Monday, 31 January 2022	44.54
C2-I4	Archway	Retrospective	Industrial Designer	US	Monday, 31 January 2022	50.42
					Average	*49.58*
					Total	*198.31*
C3-I1	Barricade	Retrospective	Engineer	Switzerland	Tuesday, 18 January 2022	49.11
C3-I2	Barricade	Retrospective	Marketing Director	US	Tuesday, 25 January 2022	48.56
C3-I3	Barricade	Retrospective	Lead Engineer	US	Tuesday, 1 February 2022	48.38
C3-I4	Barricade	Retrospective	Human Factors Engineer	US	Tuesday, 19 April 2022	43.47
					Average	*47.38*
					Total	*189.52*

Case Participant	PhD Project Code	Case Type	Role, Job Title	Country	Interview Date	Interview time length (mins:sec)
C4-I1	Amalgam	Retrospective	Engineer	UK	Friday, 14 January 2022	45.59
C4-I3	Amalgam	Retrospective	Industrial Designer	UK	Wednesday, 19 January 2022	42.45
C4-I2	Amalgam	Retrospective	Industrial Designer	Switzerland	Friday, 14 January 2022	50.07
C4-I4	Amalgam	Retrospective	Marketing Director	US	Tuesday, 19 April 2022	31.17
					Average	*42.32*
					Total	*169.28*
C5-I1	Minerva	Retrospective	Lead Engineer	US	Monday, 7 February 2022	45.02
C5-I2	Minerva	Retrospective	Industrial Designer	US	Friday, 18 February 2022	50.30
C5-I3	Minerva	Retrospective	Project Manager	US	Tuesday, 22 February 2022	24.44
C5-I4	Minerva	Retrospective	Marketing Director	US	Wednesday, 9 March 2022	35.14
					Average	*38.73*
					Total	*154.90*

L.2 Longitudinal Case Study Data Collection Summary

Case Participant	PhD Project Code	Case Type	Role, Job Title	Country	1st Interview Date	Interview time length (mins:sec)	2nd Interview Date	Interview time length (mins:sec)	3rd Interview Date	Interview time length (mins:sec)
C6-I1	Plexus	Longitudinal	Lead Engineer	US	28 April 2022	41.10	03 October 2022	10.09	Unable to be interviewed	
C6-I2	Plexus	Longitudinal	Clinical Lead	US	28 April 2022	30.49	06 September 2022	16.30	17 January 2023	19.2
C6-I3	Plexus	Longitudinal	Clinical Engineer	US	29 April 2022	48.03	07 September 2022	19.49	25 January 2023	17.41
C6-I4	Plexus	Longitudinal	Marketing Director	US	09 May 2022	36.42	21 September 2022	24.31	09 January 2023	23.24
					Average	*39.01*	Average	*17.55*	Average	*19.95*
					Total	*156.04*	Total	*70.19*	Total	*59.85*
C7-I1	Stanley	Longitudinal	R&D Engineer - Mech	Switzerland	28 April 2022	25.48	25 August 2022	15.55	06 December 2022	5.44
C7-I2	Stanley	Longitudinal	R&D Engineer - Elec	Switzerland	28 April 2022	49.03	26 August 2022	27.27	10 January 2023	8.44
C7-I3	Stanley	Longitudinal	Marketing Director	Switzerland	23 May 2022	29.14	26 August 2022	35.32	06 December 2022	8.47
					Average	*34.55*	Average	*26.05*	Average	*7.45*
					Total	*103.65*	Total	*78.14*	Total	*22.35*
C8-I1	Violet	Longitudinal	Principal Scientist	US	21 March 2022	31.30	30 August 2022	24.06	06 December 2022	20.41
C8-I2	Violet	Longitudinal	Engineering	US	22 March	36.15	30 August	25.03	07 December	18.21

Case Participant	PhD Project Code	Case Type	Role, Job Title	Country	1st Interview Date	Interview time length (mins:sec)	2nd Interview Date	Interview time length (mins:sec)	3rd Interview Date	Interview time length (mins:sec)
			Fellow		2022		2022		2022	
C8-I3	Violet	Longitudinal	Marketing Director	US	28 March 2022	44.56	30 August 2022	45.31	05 December 2022	30.11
C8-I4	Violet	Longitudinal	Lead Engineer	US	28 March 2022	29.02	No longer with the company			
					Average	*35.26*	Average	*31.47*	Average	*22.91*
					Total	*141.03*	Total	*94.40*	Total	*68.73*
C9-I1	Planetary	Longitudinal	R&D Manager	France	13 May 2022	33.51	14 September 2022	25.16	17 January 2023	20.46
C9-I2	Planetary	Longitudinal	R&D Director	US	17 May 2022	30.26	08 September 2022	19.05	17 January 2023	23.19
C9-I3	Planetary	Longitudinal	Lead Engineer	US	17 May 2022	26.36	10 October 2022	18.24	17 January 2023	26.18
C9-I4	Planetary	Longitudinal	Lead Engineer	US	18 May 2022	30.08	30 September 2022	NA	Unable to be interviewed	
					Average	*30.05*	Average	*20.82*	Average	*23.28*
					Total	*120.21*	Total	*62.45*	Total	*69.83*

Appendix J – Cross-Case Analysis Elements of the Inputs, Practices and Outputs

J.2 Cross-Case Analysis of Elements of the Inputs

	Project Strategy	Discovering Customer Insights	Engaging with Customers	Iterative Design and Development	Technology Development	Understanding the Customer Needs	Understanding the Unmet Need	Total
Business need and business case	1							**1**
Design concept prototype		1	1	1				**3**
Design risks and issues assessment						1		**1**
Identified technology	1						1	**2**
List of prioritised customer needs		1						**1**
List of questions			1					**1**
Procedure map, surgical workflow				1	1	1		**3**
Project strategy							1	**1**
Strategic direction	1							**1**
Technology landscape review					1			**1**
Uncovered preliminary customer needs						1		**1**
Unmet clinical need (clinical value)		1	1		1		1	**4**
User needs (VOC) report						1		**1**
List of validated and prioritised customer needs				1		1		**2**
Customers groups (patient, clinicians)			1					**1**
Totals	**3**	**3**	**4**	**3**	**3**	**5**	**3**	**24**

Source: Author

J.2 Cross-Case Analysis of Elements of the Practices

	Project Strategy	Discovering Customer Insights	Engaging with Customers	Iterative Design and Development	Technology Development	Understanding the Customer Needs	Understanding the Unmet Need	Total
Assembling the team	1							**1**
Consolidate, craft, validate needs statements						1		**1**
Ethnography (observation, interviews)			1					**1**
Evaluation and analysis of customer feedback from prototype (analysis for design options, brainstorming)				1				**1**
Evaluation of prototype internally and with users		1						**1**
External partnering					1			**1**
Informal discussion with customers	1							**1**
Interpreting market research data into needs						1		**1**
Market research (surgeon interview, surveys, user feedback)			1				2	**3**
Needs assessment refinement and weighting (JOC)						1		**1**
Simulated use of prototypes (observation)						1		**1**
Technology analyses and risks					1			**1**
Technology landscape search	1			1	2			**4**
Understand strategy, business, market, and budget	1							**1**
Understanding the clinical and patient problems	1	1						**2**
VOC			1				1	**2**

	Project Strategy	Discovering Customer Insights	Engaging with Customers	Iterative Design and Development	Technology Development	Understanding the Customer Needs	Understanding the Unmet Need	Total
Internal design workshops (brainstorming)	1		1			1	1	**4**
Surgeon co-design and evaluation of prototype			1	1				**2**
Simulated use of existing (products pre-clinical, cadaver)			1					**1**
Literature and IP search	1						1	**2**
Observing videos , interviews, brainstorming ideas, finding pain points		1						**1**
Developing design concept prototype (F&F, design language, testing)				1				**1**
Total	**7**	**3**	**6**	**4**	**4**	**5**	**5**	**34**

Source: Author

J.3 Cross-Case Analysis of Elements of the Outputs

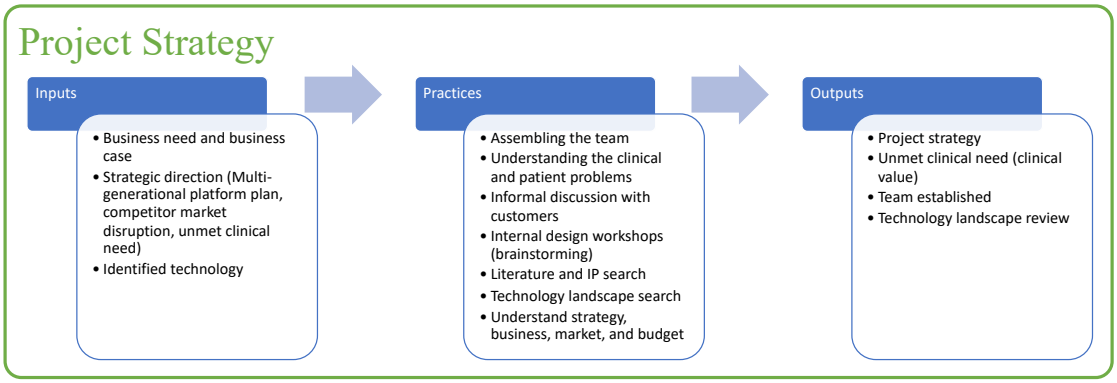
	Project Strategy	Discovering Customer Insights	Engaging with Customers	Iterative Design and Development	Technology Development	Understanding the Customer Needs	Understanding the Unmet Need	Total
Customer insights discovered and identified new needs identified from the insights		1						**1**
Design concept prototype		1	1	1		1	1	**5**
Design ideas and storyboarding			1					**1**
Discovered insights in other applications		1						**1**
Identified MVP						1		**1**
Market research report (VOC)			1					**1**
Procedure map, surgical workflow			1				1	**2**
Project strategy	1						1	**2**
Reduced scope prototype				1				**1**
Team established	1							**1**
Technology landscape review	1		1		2			**4**
Uncovered preliminary customer needs			1					**1**
Unmet clinical need (clinical value)	1						1	**2**
List of validated and prioritised customer needs						1		**1**
Design plan (design issues, killer questions)				1				**1**
Proof of concept					1			**1**
Customers groups (patients, clinicians)							1	**1**
	4	**3**	**6**	**3**	**3**	**3**	**5**	**27**

Source: Author

J.4 Inputs, Practices and Outputs

The seven insight discovery process elements for the FEI are shown below; the figures provide an overview of the inputs, practices, and outputs for each of the seven elements, which have been derived from the analysis in Section 10.2.2. Across the seven elements there were a total of 54 inputs, practices, and outputs (15, 22, 17, respectively). Refer to Appendix J for a complete listing cross-referenced with the element.

Project Strategy Element Sub-Process



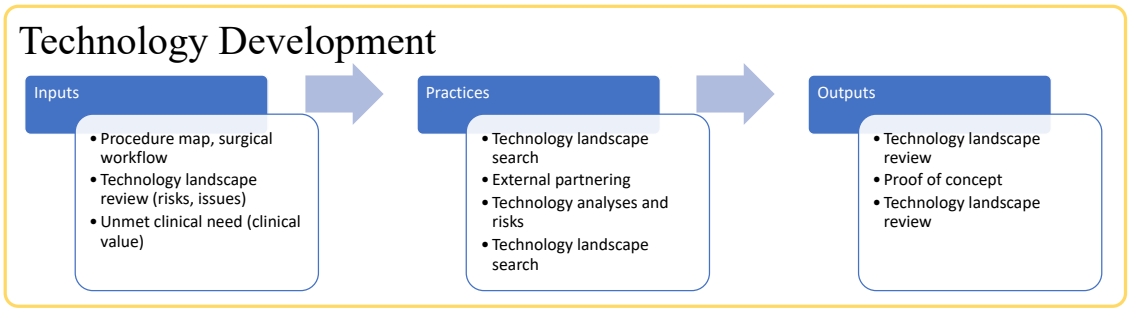
Source: Author

Figure 11-2: Understanding the Unmet Need Element Sub-Process



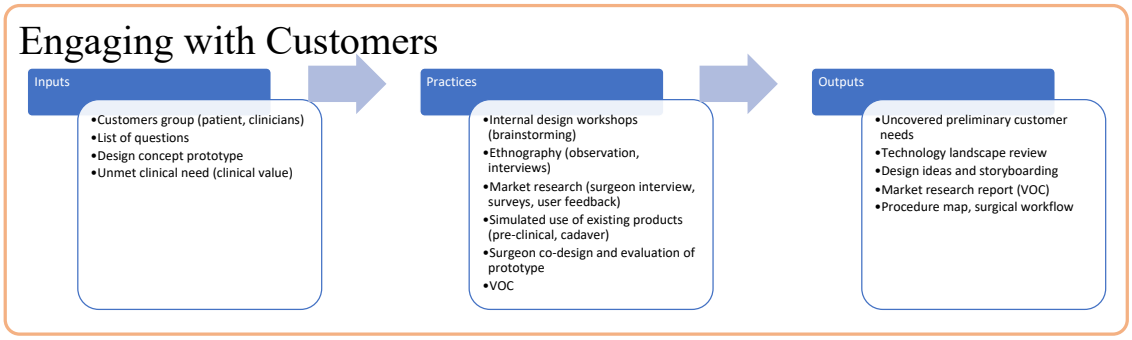
Source: Author

Figure 11-3: Technology Development Element Sub-Process



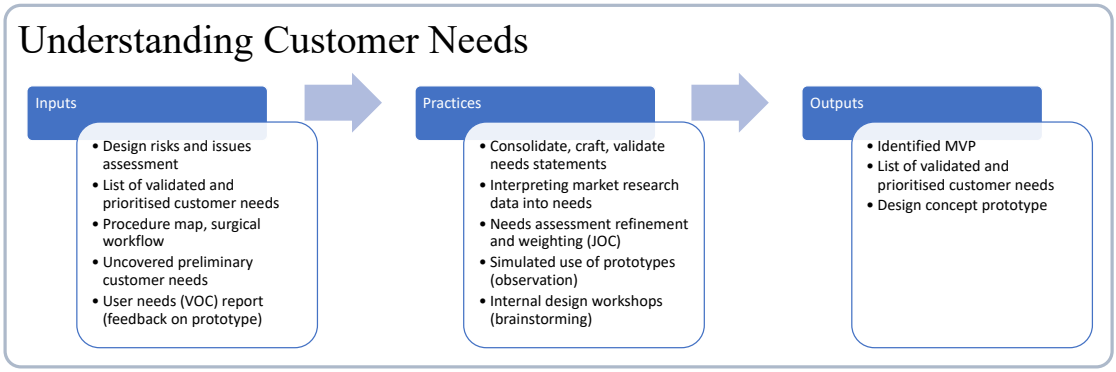
Source: Author

Figure 11-4: Engaging with Customers Element Sub-Process



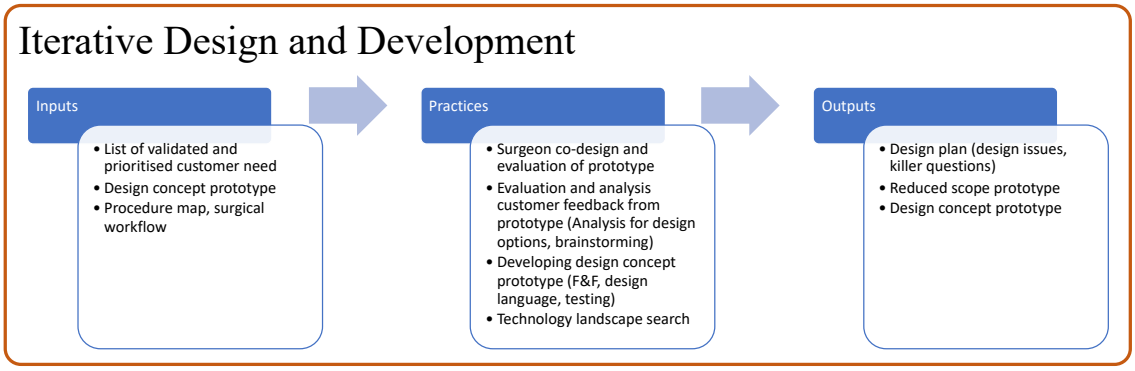
Source: Author

Figure 11-5: Understanding the Customer Needs Element Sub-Process



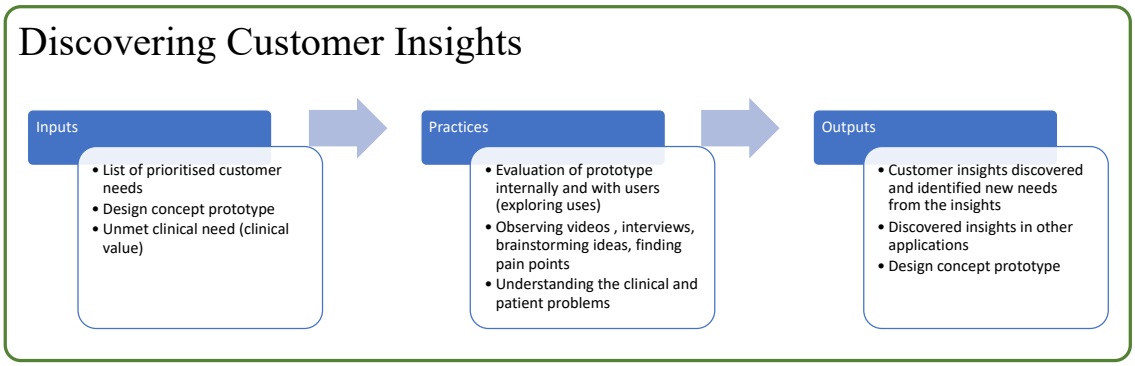
Source: Author

Figure 11-6: Iterative Design and Development Element Sub-Process



Source: Author

Figure 11-7: Discovering Customer Insights Element Sub-Process



Source: Author